

International observational campaigns of the last two eclipses in EE Cep: 2003 and 2008/9 [★]

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Received xxxxx xx, xxxx; accepted xxxxx xx, xxxx

ABSTRACT

Context. EE Cep is an unusual long-period (5.6 yr) eclipsing binary discovered during the mid-twentieth century. It undergoes almost-grey eclipses that vary in terms of both depth and duration at different epochs. The system consists of a Be type star and a dark dusty disk around an invisible companion. EE Cep together with the widely studied ϵ Aur are the only two known cases of long-period eclipsing binaries with a dark, dusty disk component responsible for periodic obscurations.

Aims. Two observational campaigns were carried out during the eclipses of EE Cep in 2003 and 2008/9 to verify whether the eclipsing body in the system is indeed a dark disk and to understand the observed changes in the depths and durations of the eclipses.

Methods. Multicolour photometric data and spectroscopic observations performed at both low and high resolutions were collected with several dozen instruments located in Europe and North America. We numerically modelled the variations in brightness and colour during the eclipses. We tested models with different disk structure, taking into consideration the inhomogeneous surface brightness of the Be star. We considered the possibility of disk precession.

Results. The complete set of observational data collected during the last three eclipses are made available to the astronomical community. The 2003 and 2008/9 eclipses of EE Cep were very shallow. The latter is the shallowest among all observed. The very high quality photometric data illustrate in detail the colour evolution during the eclipses for the first time. Two blue maxima in the colour indices were detected during these two eclipses, one before and one after the photometric minimum. The first (stronger) blue maximum is simultaneous with a “bump” that is very clear in all the $UBV(RI)_C$ light curves. A temporary increase in the I -band brightness at the orbital phase ~ 0.2 was observed after each of the last three eclipses. Variations in the spectral line profiles seem to be recurrent during each cycle. The Na I lines always show at least three absorption components during the eclipse minimum and strong absorption is superimposed on the H α emission.

Conclusions. These observations confirm that the eclipsing object in EE Cep system is indeed a dark, dusty disk around a low luminosity object. The primary appears to be a rapidly rotating Be star that is strongly darkened at the equator and brightened at the poles. Some of the conclusions of this work require verification in future studies: (i) a complex, possibly multi-ring structure of the disk in EE Cep; (ii) our explanation of the “bump” observed during the last two eclipses in terms of the different times of obscuration of the hot polar regions of the Be star by the disk; and (iii) our suggested period of the disk precession ($\sim 11\text{--}12 P_{\text{orb}}$) and predicted depth of about 2^m for the forthcoming eclipse in 2014.

Key words. Stars: binaries, eclipsing – Stars: circumstellar matter – Stars: emission-line, Be

1. Introduction

The 11th magnitude star EE Cep is a unique object among the about 40 well-known eclipsing systems with orbital periods longer than one year. The primary B5 III star is obscured by an invisible, dark secondary component of very low luminosity every 5.6 yr. The variability of the star was discovered in 1952

(epoch $E = 0$) by Romano (1956) and soon confirmed by Weber (1956), who reported observations obtained during a previous eclipse in 1947 ($E = -1$). Since then, ten consecutive primary eclipses have been observed, while a secondary eclipse has never been detected. The depths of the eclipses vary across a wide range of magnitudes from about $0^m.5$ to $2^m.0$ (see Graczyk et al. 2003). However, all of them seem to have the same features: they are almost grey and have a similar asymmetric shape (the descending branch of every eclipse has a longer duration than the ascending one). In the light curves of all the eclipses, it is pos-

[★] Tables B.1 – B.36 are available at the CDS via anonymous ftp to cdsarc.u-strasbg.fr (130.79.128.5) or via http://cdsweb.u-strasbg.fr/cgi-bin/qcat?J/A+A/544/A53

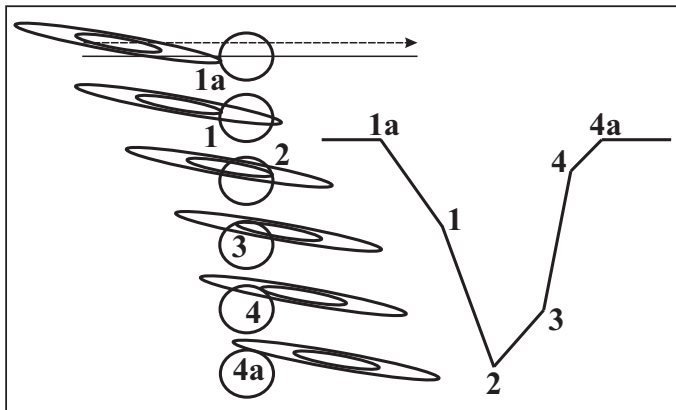


Fig. 1. Schematic representation of the eclipse geometry in the EE Cep system. The inner opaque and outer semi-transparent regions of the disk are separated. The characteristic positions of the disk and the star configuration during the eclipses (*left*) correspond to the contact times (1a, 1, 2, 3, 4, 4a) distinguished in the light curve (*right*). The figure shows a highly simplified case that ignores a number of issues such as e.g. possible inhomogeneities in the distribution of brightness on the star's surface or of the actual size of the disk.

sible to distinguish five characteristic phases (shown in Fig. 1): ingress (1-2) and egress (3-4) are preceded and followed, respectively, by extended atmospheric eclipse parts (1a-1 and 4-4a), and in the middle of the eclipses a bottom phase of variable slope (2-3) occurs.

The most plausible hypothesis to explain the observed shape of the light curve, as well as the changes in the eclipse depth during successive conjunctions and their weak dependence on the photometric band was proposed by Mikołajewski & Graczyk (1999). Their model considers the eclipses of a hot B5-type primary by an invisible, dark companion, which is most probably a dusty disk around a low-luminosity central object. The disk is slightly inclined to the orbital plane. The obscurations of the star by the opaque interior of the disk can explain the deep central parts of the eclipses, while the semi-transparent exterior areas are responsible for the observed external wings, which are similar to wings caused by atmospheric eclipses in ζ Aur type variable stars. The projection of the inclined disk onto the sky plane produces oblong shape of an obscuring body, which is tilted with respect to the direction of motion during most of the occultations. Since the eclipses are not central (the impact parameter is non-zero), the light curves observed during the eclipses have an asymmetric shape (Fig. 1). A possible precession of the disk can change both the inclination of the disk to the line of sight and the tilt of its cross-section to the transit direction. This leads to changes in the depth and the duration of the eclipses. The model briefly described above can explain the shallow ($0^m.6$), flat-bottomed eclipse observed in 1969, if we assume a nearly edge-on and non-tilted projection of the disk (Graczyk et al. 2003). This very specific configuration in 1969 is very similar to the geometry of the eclipses in the ε Aur system (see Mikołajewski & Graczyk 1999). Wide eclipsing binaries of this kind, i.e. those containing a nearly edge-on dusty disk as an eclipsing object, are very rare and apart from the two above-mentioned cases we know of only about one additional system – M2-29 – that may show some similarities (Hajduk et al. 2008).

In this paper, we present the results of two observational campaigns organized for the eclipses that occurred in 2003 and 2008/9, mainly to test the hypothesis of a precessing disk. The

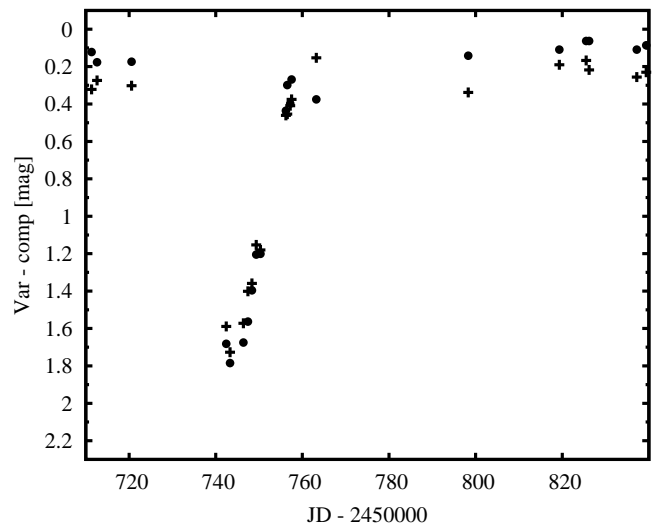


Fig. 2. *U* (dots) and *i* (crosses) light curves obtained during the 1997 eclipse of EE Cep.

results of the second campaign were systematically presented during the eclipse at a web page¹.

2. Observations

2.1. The 1997 eclipse

During the 1997 eclipse (epoch $E = 8$), the first multicolour $UBVR_{Ci}$ ($\bar{\lambda}_i \approx 7420 \text{ \AA}$) photometric observations were made using a 60 cm Cassegrain telescope at the Piwnice Observatory near Toruń (Poland) equipped with a one-channel photometer (Mikołajewski & Graczyk 1999). This eclipse was one of the deepest eclipses of all those observed in EE Cep. However, the amplitude of the minimum changes quite weakly with wavelength from about $1^m.75$ in the *U* passband to about $1^m.45$ in *i* (Fig. 2). These observations thus provided the first evidence that the eclipsing body cannot be an ordinary evolved cool star, motivating us to organize a special international observational campaign for the next two minima. A complete set of $UBVR_{Ci}$ photometry obtained in 1997 is shown in our Appendix (available online) in Table B.1.

2.2. International photometric campaigns in 2003 and 2008/9

Observers from four European countries responded to the appeal of Mikołajewski et al. (2003) to perform a precise monitoring of the subsequent eclipse of EE Cep anticipated in 2003 (epoch $E = 9$). During the organized campaign, ten telescopes were used to acquire the photometric observations (Table 1). Very high quality photometric $UBV(RI)_C$ data were obtained with very fine sampling. The eclipse turned out to be quite shallow and in accordance with the expectations, almost grey. The eclipse reached depths from about $0^m.7$ in *U* to $0^m.5$ in *I*. The preliminary photometric results of the 2003 campaign were described by Mikołajewski et al. (2005a). The results of this fruitful campaign in 2003 did not however significantly constrain the precessing disk model, and the nature of the central part of the disk and its contribution to the total flux remained uncertain. The next opportunity for resolving these uncertainties came with the most recent eclipse, which took place at the turn of 2008 (epoch

¹ <http://www.astr.uni.torun.pl/~cgalan/EEcep/>

Table 1. Overview of instruments and their involvement in photometric observations of the EE Cep eclipses since 1997.

Observatory	Country	Telescope type	Diameter [m]	Bands	Epoch	N	Table
Altan, Mt Giant	Czech Republic	Reflector	0.2m	<i>B, V, R, I</i>	10	60	B.12
Athens	Greece	Cassegrain	0.4m	<i>B, V, R, I</i>	9, 10	176	B.2, B.24
Białków	Poland	Cassegrain	0.6m	<i>B, V, R, I, Hα^W*, Hα^N*</i>	9, 10	109	B.3, B.13
Green Island	North Cyprus	Ritchey-Chrétien	0.35m	<i>B, V, R, I</i>	10	35	B.14
Hankasalmi	Finland	RCOS	0.4m	<i>B, V, R, I</i>	10	28	B.25
Furzehill, Swansea	United Kingdom	Schmidt-Cassegrain	0.35m	<i>B, V, R, I</i>	10	68	B.15
Kraków	Poland	Cassegrain	0.5m	<i>U, B, V, R, I</i>	9, 10	336	B.4, B.27
Kryoneri	Greece	Cassegrain	1.2m	<i>U, B, V, R, I</i>	9, 10	42	B.5, B.21
GRAS, Mayhill	USA (NM)	Reflector	0.3m	<i>B, V, I</i>	10	127	B.31
Navas de Oro, Segovia	Spain	Reflector	0.35m	<i>V</i>	10	16	B.16
Ostrava	Czech Republic	Newton	0.2m	<i>B, V, R, I</i>	10	24	B.26
Ostrava	Czech Republic	Schmidt-Cassegrain	0.3m	<i>B, V, R, I</i>	10	4	B.17
Piszkéstető	Hungary	Schmidt	0.6/0.9m	<i>B, V, R, I</i>	9	12	B.11
Piwnice**	Poland	Cassegrain	0.6m	<i>U, B, V, R, I, c*, Hβ*</i>	8, 9	612	B.1, B.6
Piwnice	Poland	Cassegrain	0.6m	<i>U, B, V, R, I</i>	10	470	B.6
Rolling Hills, Clermont	USA (FL)	Reflector	0.25m	<i>B, V</i>	10	80	B.32
Rozhen	Bulgaria	Ritchey-Chrétien	2m	<i>U, B, V, R, I</i>	9, 10	20	B.7, B.18
Rozhen	Bulgaria	Schmidt	0.5/0.7m	<i>U, B, V, R, I</i>	9, 10	33	B.8, B.19
Rozhen**	Bulgaria	Cassegrain	0.6m	<i>U, B, V</i>	9	18	B.9
Rozhen	Bulgaria	Cassegrain	0.6m	<i>U, B, V, R, I</i>	10	34	B.20
Skinakas	Greece	Ritchey-Chrétien	1.3m	<i>U, B, V, R, I</i>	9	44	B.10
Sonoita	USA (AZ)	Reflector	0.5m	<i>B, V, R, I</i>	10	349	B.22, B.23
Suhora	Poland	Cassegrain	0.6m	<i>U, B, V, R, I</i>	10	196	B.30
Tenagra-II	USA (AZ)	Ritchey-Chrétien	0.81m	<i>U, B, V, R, I</i>	10	20	B.28

Notes. *N* is the number of individual brightness determinations summed over all the photometric bands. The last column specifies the number of the table with the original data. (*) $H\alpha^W$ and $H\alpha^N$ are intermediate width (FWHM ≈ 200 Å) and narrow (FWHM ≈ 30 Å) photometric bands, both centred at the $H\alpha$ spectroscopic line. *c* and $H\beta$ are narrow (FWHM ≈ 100 Å) photometric bands centred on $\lambda = 4804$ Å and at the $H\beta$ spectroscopic line, respectively. (**) In these two cases, the photomultipliers were used as the light receiver instead of CCD.

$E = 10$), with a minimum on January 10, 2009. An invitation to participate in an observational campaign (Gałań et al. 2008) attracted strong interest. Twenty telescopes located in Europe and North America were involved in the photometric observations (Table 1), which provided a more comprehensive multi-colour and temporal photometric coverage than for any previous eclipse. The first results and the $UBV(RI)_C$ light curves in graphical form were published by Gałań et al. (2009). Surprisingly, the last eclipse turned out to be the shallowest in the observing history of EE Cep, reaching a depth of only $\sim 0^m.5$ in U and nearly $\sim 0^m.4$ in I_C .

The strong interest inspired by Mikołajewski et al. (2003) and Gałań et al. (2008) resulted in many observations. The original data and the observatories that sent them are presented in Tables B.2–B.11 for the 2003 eclipse ($E = 9$) and Tables B.12–B.32 for the 2008/9 ($E = 10$) eclipse, respectively. The three standard stars “ a ” = BD +55°2690, “ b ” = GSC-3973:2150, and “ c ” = BD +55°2691 have been recommended by Mikołajewski et al. (2003). Most magnitudes were evaluated with respect to either the standard star “ a ” (Tables B.2–B.20) or all three standard stars “ a ”, “ b ”, and “ c ” independently (Tables B.24–B.32). One set of data (Table B.21) were obtained only with respect to standard star “ c ” because of the small field of view of the instrument used. The data in Tables B.2–B.21 and B.24–B.32 are shown in differential form. Two sets of data, from Sonoita Research Observatory (Tables B.22–B.23), were obtained partly with respect to other standard stars (see Table B.22), and we show them as apparent magnitudes. They were transformed to a differential form using the known brightness of star “ a ” from Mikołajewski et al. (2003). The original differential magnitudes obtained with the three standard stars were calculated with respect to star “ a ”, us-

ing the average differences between the standard stars ($\overline{a-b}$) and ($\overline{a-c}$). All of the mean values in Tables B.24–B.32 for variable star “ v ” were calculated according to the expression $[(v-a) + (v-b) - (\overline{a-b}) + (v-c) - (\overline{a-c})]/3$ for each filter, excluding ΔV and ΔR_C data in Table B.25. For this last set of data, the differences ($v-a$) were not recorded by the observers, hence the reduced average values were calculated using the expression $[(v-b) - (\overline{a-b}) + (v-c) - (\overline{a-c})]/2$, where the $\overline{a-b}$ and $\overline{a-c}$ VR magnitudes were adopted from Mikołajewski et al. (2003). All data were corrected for the differences between the particular photometric systems. The CCD data from Kraków were adopted as a zero-point, owing to their high quality and good coverage during both the eclipses. Original individual data points obtained close to the eclipses are presented in Fig. 3, which is composed of about 2500 measurements. The phases were calculated with ephemeris (Mikołajewski & Graczyk 1999)

$$JD(Min) = 2434344.1 + 2049^d.94 \times E. \quad (1)$$

The photometric observational data were further processed by averaging the groups of neighbouring points. In the case of the previous eclipse at $E = 9$, for which the photometric measurements were obtained only in Europe, each point in the light curves represents the average of all measurements obtained in a given passband during a single night. The V light curve constructed in this way was complemented by the data obtained independently for this eclipse by Samolyk & Dvorak (2004), which we shifted by $+0^m.02$ onto the reference system. The last eclipse at $E = 10$ was observed from two continents, Europe and North America. The measurements obtained during each day form groups of points separated by about one-third of a day

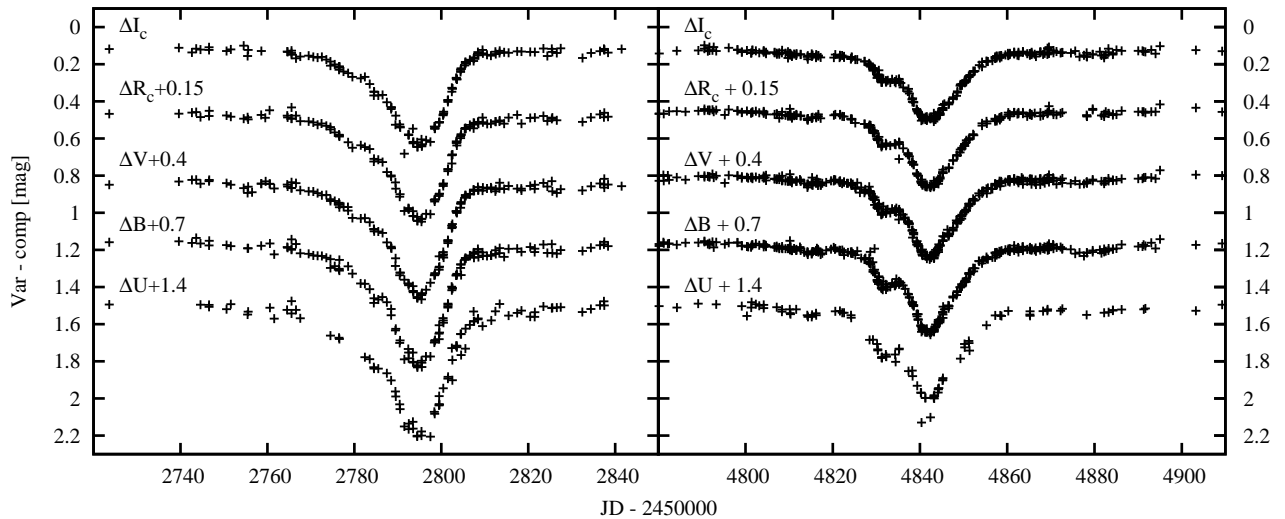


Fig. 3. All of the approximately 800 individual photometric $UBV(RI)_C$ measurements obtained during the 2003 eclipse (left; Tables B.2-B.11) and all of the more than 1600 observations obtained during the 2008/9 eclipse (right; Tables B.12-B.32).

Table 2. Overview of the instruments involved in the spectroscopic observations during the three last eclipses at epochs $E = 8$, $E = 9$, and $E = 10$. N is the number of spectra.

Observatory	Country	Telescope type	Diameter [m]	Spectrograph	Res. power	Spectral reg.	Epoch	N
NOT, La Palma	Canary Isl.	Ritchey-Chrétien	2.56	FIES-Echelle	48000	3680-7280 Å	10	4
Rozhen	Bulgaria	Ritchey-Chrétien	2.0	Coude	15000, 30000	H α , H β , Na I	8, 9, 10	38
Asiago	Italy	Cassegrain	1.82	Echelle	20000	4600-9200 Å	9	5
SPM	Mexico	Ritchey-Chrétien	2.12	Echelle	18000	3700-6800 Å	9	1
DDO	Canada	Cassegrain	1.88	Cassegrain	16000	H α , Na I	9	16
Terskol	Russia	Ritchey-Chrétien	2.0	Echelle	13500	4200-6700 Å	9	7
Asiago	Italy	Cassegrain	1.82	AFOSC/echelle	3600	3600-8800 Å	9	3
Piwnice	Poland	Schmidt-Cassegrain	0.9	CCS	2000 – 4000	3500-10500 Å	9, 10	26

and should not be averaged together. In the light curves of this eclipse, each point represents the average of all measurements obtained in a given filter during the first or second part of a particular Julian day. The accuracy of the photometry obtained in this way is excellent, reaching a few mmag. The resulting mean points of the average light curves, together with the formal standard deviations for particular observations, are shown in Table B.35.

2.3. Spectroscopic data collected in 2003 and 2008/9

For several decades until the eclipse at epoch $E = 9$ in 2003, changes in EE Cep's spectrum outside and during eclipses had been poorly studied, whereas the photometric behaviour during the eclipses had been relatively well characterized. The situation improved significantly after the observational campaign in 2003. Seven observatories located in Europe and North America took part in the observations (using the instruments listed in Table 2), collecting spectra at low and high resolution. The spectral observations covered various phases of the eclipse, revealing changes in the line profiles (mainly H α , Na I, H β , and Fe II) not only during the photometric eclipse but even more than two months before and after the minimum (Mikołajewski et al. 2005b). Unfortunately, during the last campaign at the turn of 2008 (epoch $E = 10$) only a small number of spectra were obtained, with only three instruments. The new spectra complement those obtained during the previous epoch, because a sig-

nificant number of these spectra were acquired during orbital phases that had not been previously covered.

With this paper, we make available a large number (100) of spectra, most of which were, however, obtained with moderate resolution and/or cover a narrow spectral range, containing mainly H α or Na I spectral lines. In addition, they were clustered near the eclipse – the spectroscopic observations have insufficient temporal coverage throughout the orbital phase to use them in studying changes in the radial velocities. The list of spectra and instruments together with some additional information are given in Table B.36. All these spectra were heliocentric corrected and some of them (obtained at Rozhen Observatory and DDO), which cover a narrow spectral range (~ 100 -200 Å), were normalized to the continuum. The low resolution spectra obtained at Piwnice Observatory were flux calibrated. All spectra are available as FITS files at the CDS.²

3. Results

3.1. Light and colour changes during the last two eclipses

Thanks to the aforementioned observational campaigns, it has been possible for the first time to analyse colour evolution during the eclipses. In Fig. 4, the mean B light curves and the colour indices for both of the last eclipses are presented. The 2003 and 2008/9 eclipses reached their minima on Julian days

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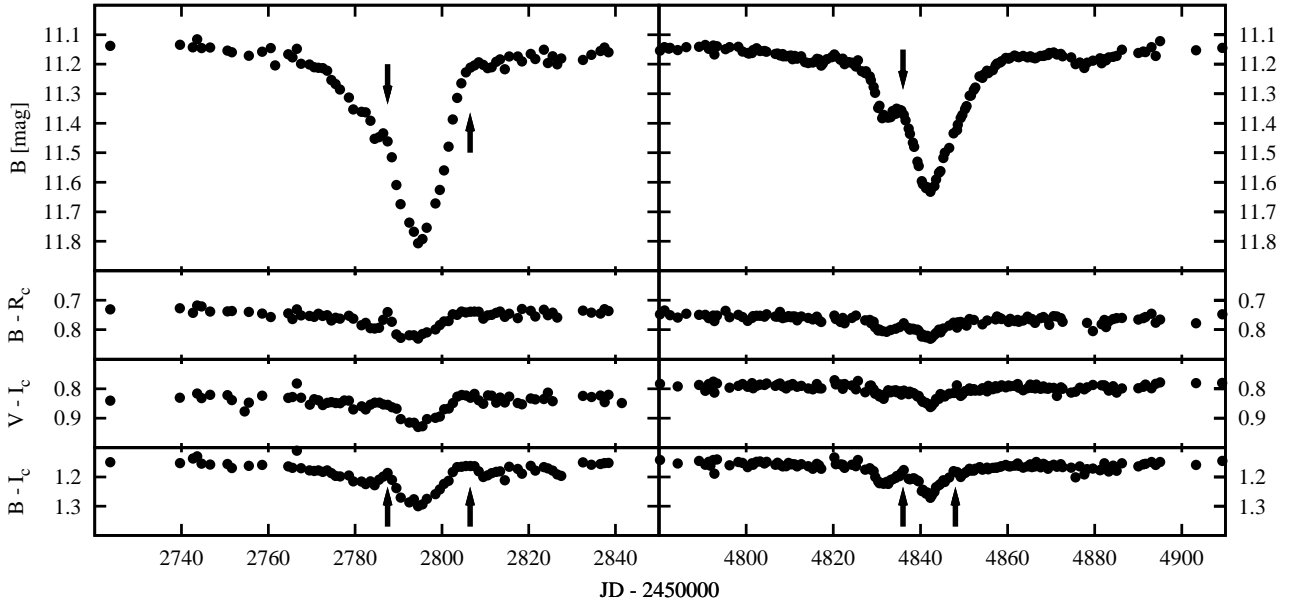


Fig. 4. Average points from Table B.35 of the 2003 eclipse (*left*) and the 2008/9 eclipse (*right*). The B light curves (*top*) and three colour indices (*bottom*) are presented. Arrows denote times of blue maxima.

$JD = 2452795$ and $JD = 2454842$, respectively. The small timing residuals ($O - C$, observations minus calculations) $+1^d.44$ and $-1^d.5$ with respect to the ephemeris [Eq. (1)] did not change this significantly. The Mikołajewski & Graczyk (1999) ephemeris was used (unchanged) for orbital phasing to produce all the observational data in this paper. The colour indices for the 2003 eclipse show two blue maxima, about nine days before and after the mid-eclipse. Two weak maxima in the B light curve are also clearly visible. Similar features also occur in the 2008/9 eclipse but the “bump” (at $JD\ 2454836$) preceding the minimum (Fig. 3 and 4) is much more pronounced than previously. The differences in the phase and strength of these features can be caused, such as the depth of eclipses, by changes in the spatial orientation of the disk.

The observed variations in the I passband after the eclipses could give additional support to this idea. In Fig. 5, the I -band light curve obtained over 13 years, from 1996 to 2010, is shown. About one year after each eclipse, near the orbital phase ~ 0.2 , an increase in I -band brightness appears. The recurrence and rapid variation during these events allow us to speculate that this increase may be caused by proximity effects when the components are close to periastron. If this is true, then the orbit in the EE Cep system must be significantly eccentric. An interesting correlation – the brightening events appear to be stronger when the eclipses are deeper – may indicate that there are changes in the disk projection and this may be an additional observational argument for precession of the disk. The quite large amplitude of variability outside the eclipse in the I passband (which is not clearly visible at shorter wavelengths) also indicates that the contribution of a dark component (disk or/and central object) to this band has to be significant. The cool component becomes readily noticeable at the red edge of the visible spectrum, and in the near infrared (the JHK bands) it might dominate the observed fluxes.

3.2. Variations in the spectrum

The most important results of the spectroscopic observations obtained during the 2003 campaign seem to be the conclu-

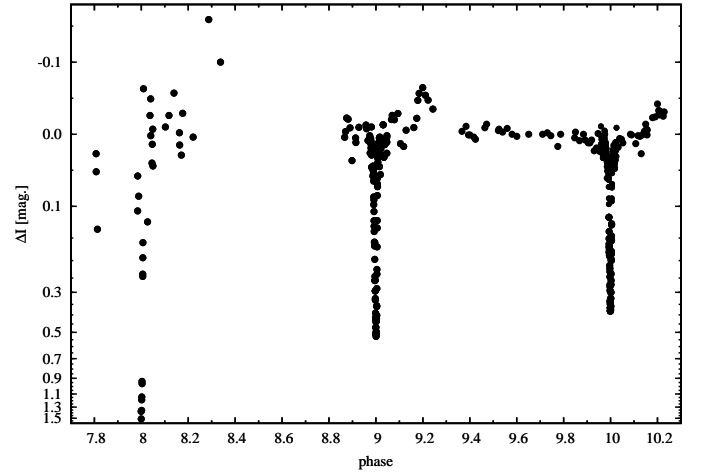


Fig. 5. Differential I magnitudes of EE Cep obtained at Piwnice Observatory during the 13 years from 1996 to 2010. The zero value corresponds to the level of the average brightness outside (phases 0.4–0.8) eclipses. Below $+0^m.1$ (i.e. for magnitude changes smaller than $+0^m.1$) an artificial, strongly non-linear scale is used to reduce the contrast in the amplitude of the changes during and outside eclipses (thus, the relatively small variations outside the eclipses can be seen and compared with the depth of the eclipses).

sions regarding the nature of the hot component. The emission and absorption components of the Balmer and Fe II line profiles in the spectra obtained around the 2003 eclipse imply that the hot component is a rapidly rotating Be star surrounded by a highly inclined emitting gaseous ring (Mikołajewski et al. 2005b). These line profiles show the same pattern during the 2008/9 eclipse (compare Fig. 6 with Fig. 2 of Mikołajewski et al. 2005b). A comparison of the Balmer H8–H11 absorption lines in the spectrum of EE Cep with theoretical profiles (Fig. 7) gives $v \sin i \approx 350 \text{ km s}^{-1}$ (Gařan et al. 2008), which implies that there has been a strong equatorial gravitational darkening. The rota-

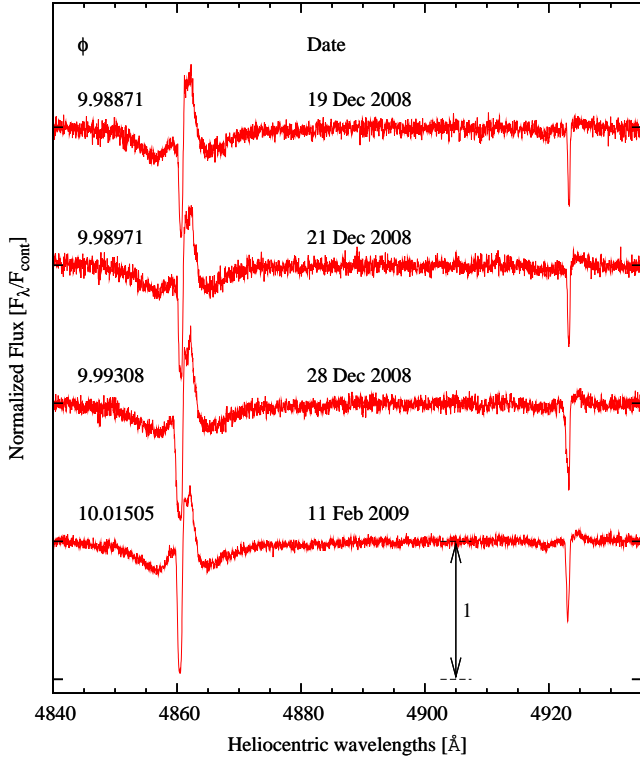


Fig. 6. $H\beta$ and $Fe\ II$ line profiles in the spectra obtained during the 2008/9 eclipse with the Nordic Optical Telescope (NOT, La Palma). The spectra are vertically offset for clarity.

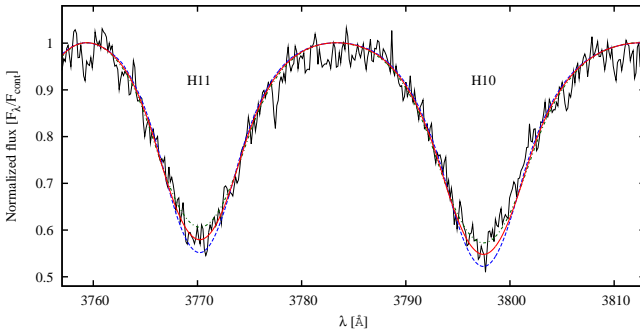


Fig. 7. The Balmer H10 and H11 line profiles in the spectrum of EE Cep taken on 11 Aug 2003 with an Echelle spectrograph on the 2.12 m telescope in SPM Observatory in Mexico. The best fit was obtained for a synthetic spectrum with: $T_{\text{eff}} = 15000\text{K}$, $\log g = 3.5$, $[Fe/H] = 0$, and $v \sin i = 350\text{ km s}^{-1}$ (solid line). Two poorer fits calculated with different values of the rotational velocity, $v \sin i = 300\text{ km s}^{-1}$ (dashed line) and $v \sin i = 400\text{ km s}^{-1}$ (dash-dotted line), are shown for comparison purposes.

tional velocity of the Be star in the EE Cep system is very close to the critical value. It must lead to a continuously strong radial outflow of the gas stream from the equator, which is confirmed by the existence of the gaseous ring – a characteristic feature of Be-type stars (Mikołajewski et al. 2005b).

Figures 8–10 show the evolution of the $H\alpha$ and $Na\ I$ line profiles in which additional absorption components appeared during both of the last two eclipses. Towards the mid-eclipse, an

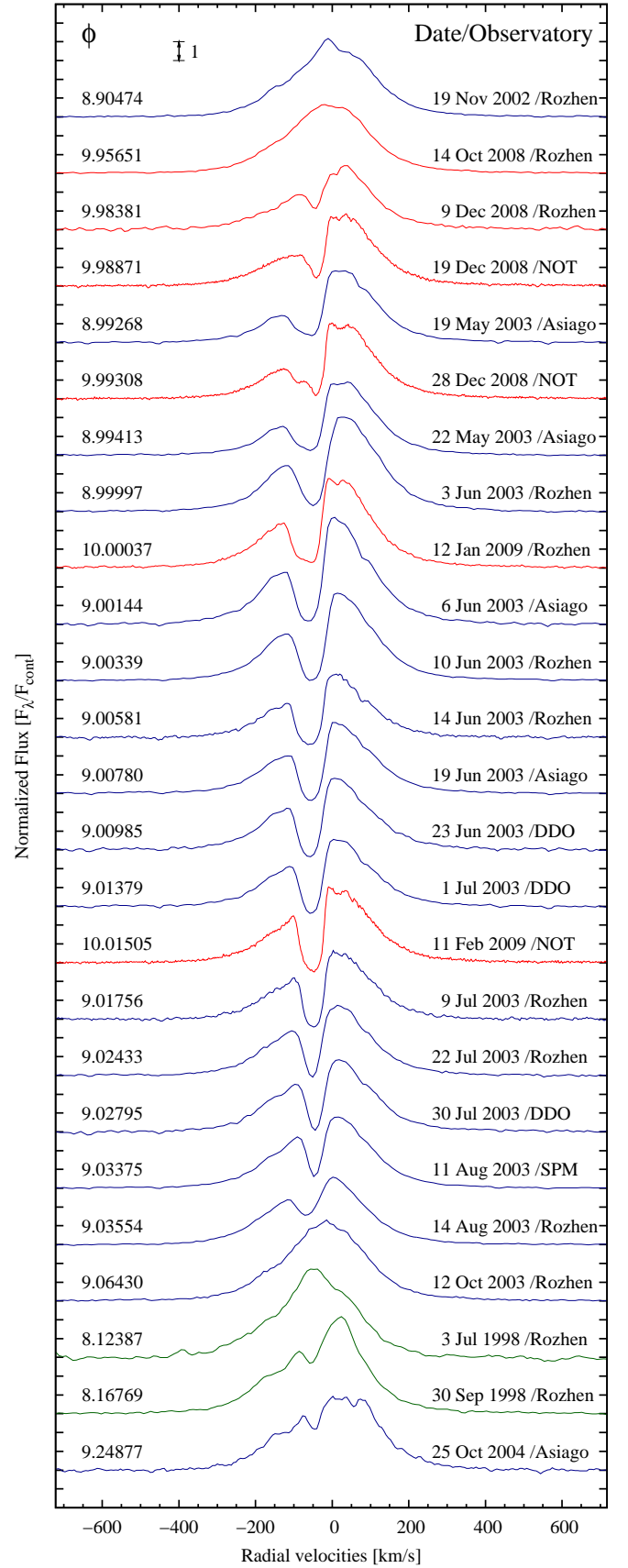


Fig. 8. Representative examples of $H\alpha$ line profiles in the spectra obtained near the eclipses at epochs $E = 10$, $E = 9$, and $E = 8$ (in the electronic version of this paper, the profiles have different colours: red, blue, and green, respectively). The spectra are vertically offset for clarity.

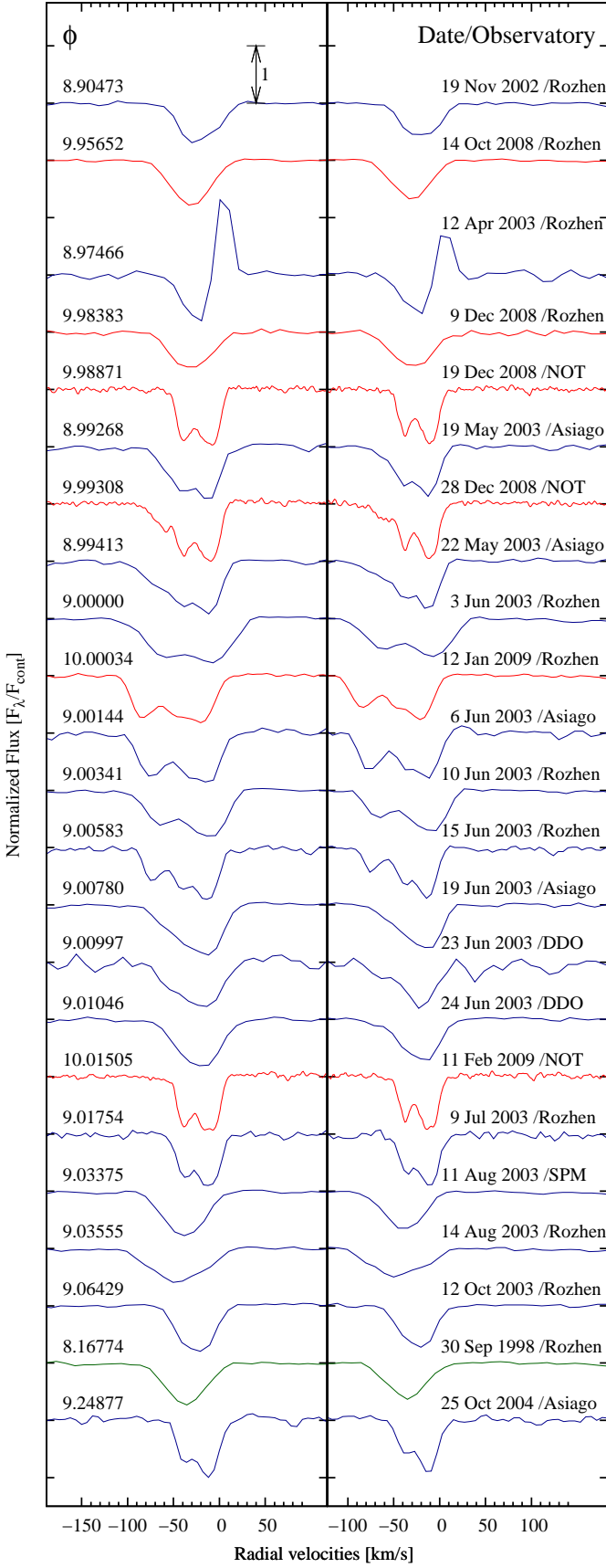


Fig. 9. Representative examples of Na I doublet line profiles in the spectra obtained near the eclipses at epochs $E = 10$, $E = 9$, and $E = 8$ (in the electronic version of this paper, the profiles have different colours: red, blue, and green, respectively). The spectra are vertically offset for clarity.

absorption component in the $H\alpha$ profile grows, and during the minimum it is very deep and broad. The sodium doublet line profiles in the minimum show a multi-component structure and we can discern at least two additional absorption components shifted towards blue wavelengths, first at a velocity of about -40 km s^{-1} and then at about -70 km s^{-1} (Fig. 11).

In a few high-resolution spectra from the Rozhen, NOT, Asiago, and Terskol observatories, we can see $H\alpha$ and $H\beta$ lines. The spectra from NOT and Terskol contain higher order Balmer lines, which are, however, underexposed, permitting us to see only that the emission is weakening and the broad and strong absorption features of the Be star begin to dominate. The only spectrum displaying absorption from $H\alpha$ to $H13$ - $H14$ is the SPM spectrum (see Table 2) obtained during the 2003 eclipse. In this spectrum, strong absorption in the Be star dominates and the higher order emission Balmer lines are absent (see Fig. 7). In the case of other lines of the Be star, in a few spectra, the He I 5876 Å, 4471 Å, and Mg II 4481 Å lines appear to be present but are barely visible. In the spectra from CCS and Asiago, the emission triplet Ca II (8498 Å 8542 Å 8662 Å) and the O I 8446 Å line are visible. Because of the small number of lines in the Be star spectrum and their weakness and large width, it was impossible to extract reliable information about changes in the radial velocities of the hot component.

The spectra obtained during the two most recent eclipses suggest that the behaviour of the spectral line profiles might not change between eclipses. A unique spectrum was obtained at phase ~ -0.025 before the 2003 eclipse when both lines of the Na I doublet showed a P Cyg profile. If this is a sign of outflow from the Be star, then this implies that the eclipses occur relatively close to periastron. At orbital phases far from the eclipses, absorption structures are indeed sometimes appear imposed on the emission lines indicating that there are large amounts of loose gaseous clouds in the system, which could support such a scheme (see e.g. Fig. 8 – $H\alpha$ line profiles at phases ~ 0.17 and ~ 0.25). On the other hand, these structures are observed during the brightening event observed in the I band at an orbital phase ~ 0.2 .

The changes of the spectral line profiles during phases close to the photometric eclipses allowed us to estimate the sizes of the eclipsing dusty disk and gaseous ring around the Be star (Mikołajewski et al. 2005b). The disappearance of the bluest component of the Na I doublet at a phase of about 0.011 suggests that the radius of the eclipsing cloud producing the Na I lines is at least $6R_{\text{Be}}$. The shell absorption in $H\alpha$ rapidly decays about 2.5 months after minimum (at phase ~ 0.036), which suggests that the gaseous ring around the Be star producing the $H\alpha$ emission is almost twice the size of the eclipsing cloud, i.e. $\gtrsim 10R_{\text{Be}}$.

4. Modelling of the eclipse light curves, precession of the disk, and discussion

4.1. Numerical code and basic assumptions

Although similar to ϵ Aur and maybe even M2-29, EE Cep is nevertheless quite a unique system, and existing tools do not seem to be suitable for analysing this system. To model the brightness and colour variations during the eclipses and changes from epoch to epoch, possibly depending on precession, it was necessary to develop our own, original numerical code.

The models require the adoption of some quite simplistic assumptions. An axially symmetric, circular, flat disk with an r^{-n} density profile was assumed in all cases. The disk was considered to be geometrically thin, although we highlight that two

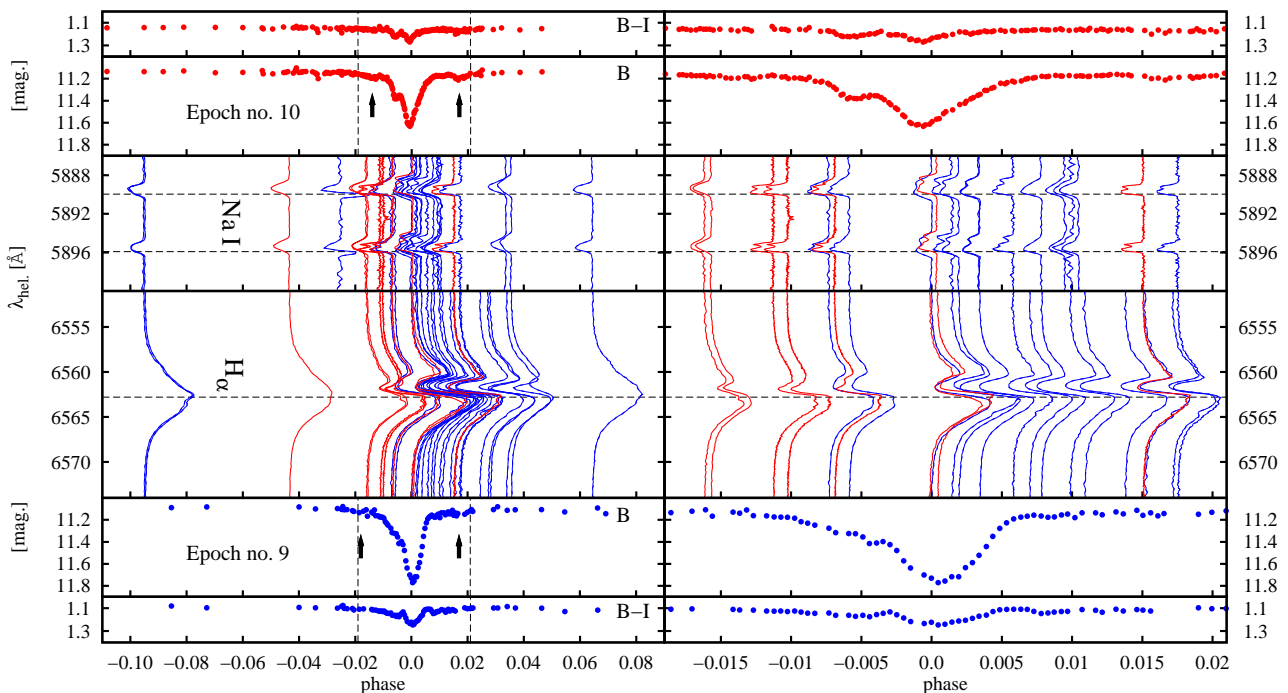


Fig. 10. The B and $B - V$ light curves of the 2003 (bottom) and 2008/9 (top) eclipses. In the middle panel, we present all available line profiles of the Na I doublet and $\text{H}\alpha$ for epoch 9 (superposition of two lines: thick dashed with thin solid) and 10 (solid line). The positions of the continuum levels refer to the orbital phases. The right-hand panels show a zoom of the central part of left-hand panels as indicated by vertical dashed lines. The arrows indicate the shallow minima in the external parts of the eclipses observed about 35 days before and after mid-eclipse at both last epochs (both last eclipses seem to be longer than expected and lasted about 90 days).

different approaches are possible with our code. One is to assume a disk thickness H and integrate the density of the matter in the disk. The second approach, which is more efficient for the calculation, is to assume that the disk has a negligible thickness (in reality zero thickness in the model). Changes in the optical depth depending on the disk inclination could also be taken into account ($\tau \sim |\cos i_d|$). The outer disk radius was assumed to be six times the equatorial radius of the Be star ($R_{d0} = 63.4R_\odot$), i.e. approximately the minimal possible radius that can be estimated from the contact times in the eclipse light curves (Mikołajewski et al. 2005a). A possible additional contribution of radiation from the eclipsing body (disk and/or its central object) to the total flux (commonly called “the third light”) and scattering of Be star radiation off the disk particles have been neglected. We assumed that the matter of the disk absorbs radiation selectively in accordance with interstellar extinction. The passband-dependent absorption coefficients were estimated based on the total value of the reddening, which increased by $\Delta E_{B-V} \approx 0.05$ during mid-eclipse in 2003.

The Be star parameters that could not be reliably calculated during the modelling process had to be entered as inputs into the model. Our spectra show that the hot component has an effective temperature $T_{\text{eff}} = 15000 \text{ K}$ and $\log g = 3.5$, implying that it is a B5III or B4II type star. With the spectral type and luminosity class, the stellar effective temperature and luminosity $L = 3500L_\odot$ can be determined using the statistical relations of de Jager & Nieuwenhuijzen (1987). Comparing the resulting values with the theoretical evolutionary models for stars with moderate and high masses (Claret 2004), via interpolation, the mass range $M_{\text{Be}} = 8.0 \pm 2.2M_\odot$ was estimated for the mass of the Be star in EE Cep. A mean stellar radius was estimated with the Stefan-Boltzmann law. For a description of the

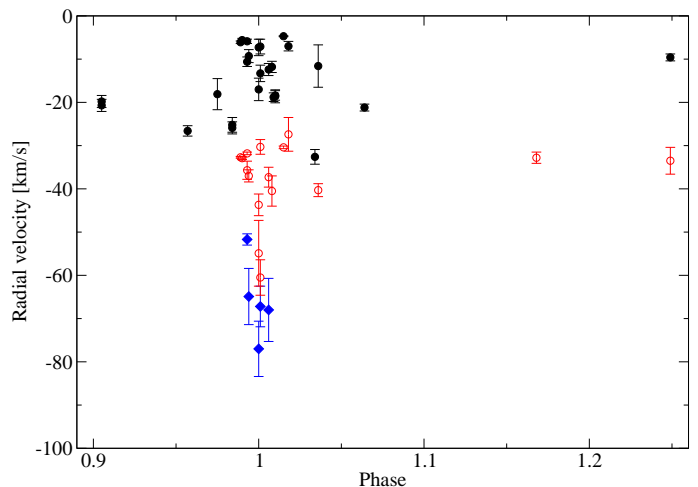


Fig. 11. Radial velocities of the three components of the sodium doublet Na I lines obtained from the spectra of five observatories (NOT, SPM, DDO, Asiago, and Rozhen). The main stellar component is shown with filled circles, and two components from the disk blue-shifted by about -40 and -70 km s^{-1} are shown with open circles and filled diamonds, respectively.

star’s surface, its shape and radiation, we used the model described by Cranmer & Owocki (1995) and Owocki et al. (1994) in our program. The model takes into account both the oblateness of the star and gravity darkening using a Roche model and a von Zeipel ($F \sim g \rightarrow T_{\text{eff}} \sim g^{0.25}$) law. By comparing of the critical rotational velocities that characterize each pair of mass and radius with the observed rotational velocity, which for the

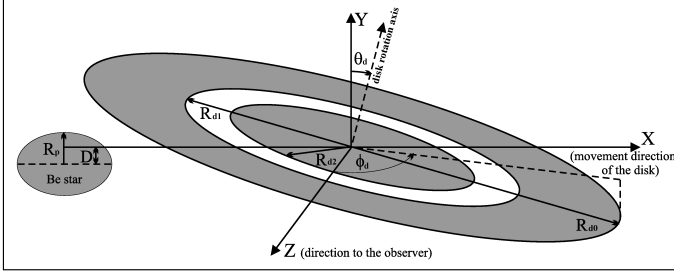


Fig. 12. Schematic explanation of the geometrical parameters in the special case when the precession axis of the disk (the symmetry axis of the conical surface over which the rotation axis of the disk moves cyclically with the precession period P_{prec}) is parallel to the Y axis of the coordinate system (i.e. it is perpendicular to the orbital plane). Our code allows this axis to be inclined by angles θ_{prec} and ϕ_{prec} in a similar way to the inclination of the rotation axis.

adopted inclination $i = 90^\circ$ is $v = 350 \pm 50 \text{ km s}^{-1}$, we constrained the possible masses to the range $5.9M_\odot \lesssim M_{\text{Be}} \lesssim 7.9 M_\odot$, i.e. the range in which stars do not disintegrate as a result of rapid rotation. We eventually decided to fix the basic parameters of the Be star in our model to a mass $M = 6.7M_\odot$, mean radius $\bar{R}_{\text{Be}} \approx 9.0R_\odot$ (with equatorial to polar radius ratio $R_{\text{eq}}R_p^{-1} \approx 1.44$, giving equatorial and polar radii, respectively, $R_{\text{eq}} \approx 10.57R_\odot$ and $R_p \approx 7.34R_\odot$), luminosity $L = 3500L_\odot$, and rotational velocity at the equator $V_{\text{eq}} = 325 \text{ km s}^{-1}$. To perform a χ^2 minimization, our numerical code was equipped with the simplex algorithm. This procedure used the method described in Brandt (1998) and the flowchart of Kallrath & Milone (1999).

The solutions were carried out using the $UBV(RI)_C$ light curves. In general, several parameters were treated as free parameters: the impact parameter D , the mid-eclipse moment T_0 (in the sense of the minimum proximity of the star and the disk centres in the projection on the sky plane), the relative tangential velocity of the star and the disk V_i , the inclination of the disk ($90^\circ - \theta_d$), an angle related to the disk precession phase ϕ_d , the absorption coefficient κ_s representing the contribution by the grey extinction and the central disk density ρ_c expressed in arbitrary units. The geometrical parameters (D , θ_d , ϕ_d , R_{d0} , R_{d1} , and R_{d2}) describing the disk sizes and orientation in the models are presented in Fig. 12. The code allows additional disk radii R_{di} for $i \leq 5$ to be defined, making it possible to take into account the presence of one or two gaps in the disk and the central opening.

4.2. A solid or a gapped disk model?

We used our code to model the last two eclipses with a solid disk causing the eclipses. This model is consistent with the global changes in the light curves and colours (it fits the depth and the shape of the eclipses), especially for the 2003 eclipse (see Appendix A, Fig. A.1). However, this model has trouble in explaining the two blue maxima in the colour evolution that appeared during the last two eclipses, roughly symmetrically a few days before and after the photometric minimum.

We tried to explain these blue maxima based on a hot star being rotationally darkened at the equator and brightened at the poles, and assuming that the eclipsing disk is divided into two parts by a gap. For a hot Be star such as EE Cep, convection is impossible in the envelope and we can expect the darkening effect to occur in pure von Zeipel (1924) form. Since the star rotates with a velocity very close to the critical value, the grav-

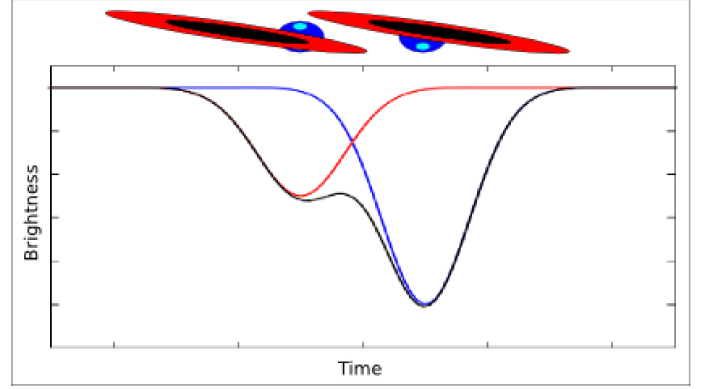


Fig. 13. Schematic explanation for the formation of the bump in the light curves. The configurations of the star and the disk at the first and second minima are shown at the top.

ity darkening effect can result in a difference between the polar and the equatorial temperatures of as much as 5–6 thousand Kelvins. Thus, the appearance of the hot polar area in the gap could be observed as the blue maxima. Gařan et al. (2008) considered and briefly described a model with a disk that has a concentric gap for the 2003 eclipse. In the current work, an attempt has been made to create a similar model for the last two eclipses together, by taking into account the precession period P_{prec} as an additional free parameter. Although this model seemed to be appropriate when the 2003 eclipse alone is considered, it does not work well when we consider the two eclipses together (see the online Appendix A: Fig. A.2). The model indeed generates colour changes and blue maxima of the same order as observed during the 2003 eclipse. However, its predictions are inconsistent with the observations, because the shallower eclipses should be accompanied by a less pronounced “bump” and associated blue maximum, in contradiction to the case of the 2003 and 2008/9 eclipses taken together. The “bump” at JD 2454836 in the last eclipse ($E = 10$) seems to be too strong to be explained entirely by a gap in the disk.

After many attempts to model the light changes during the eclipses, especially the shallow ones, we realized that another mechanism, connected with the flattening of the Be star, could be helpful in explaining the “bump”. For example, we consider the case when the disk has an inclination close to 90 degrees (when the eclipse is shallow) and the tilt with respect to the direction of motion is high (we expect that this could occur for the eclipses at epochs $E = 9$, $E = 10$). The temporal superposition of the two minima should be observed, corresponding to the successive obscuration of the two hot poles separately, at significantly different times (see Fig. 13). The first minimum is shallower and the second deeper, because of the non-zero value of the impact parameter, which reduces the obscuration of one of the poles, and because the outer part of the disk is more transparent than the inner part. The condition for the occurrence of the “bump” is a sufficiently long temporal separation of the two minima. Models generated using our numerical code at various precession phases suggest that the “bump” would disappear in the deep eclipses and be stronger in the shallow ones, matching what we observe. Although this scenario is very promising, it may not match the observed colour changes. The main problem is the second blue maximum, which appears in both of the last eclipses (during 2003 and 2008/9), although it is already very weak during the last one. We speculate that the reason for the occurrence of the second blue maximum may be (i) a concen-

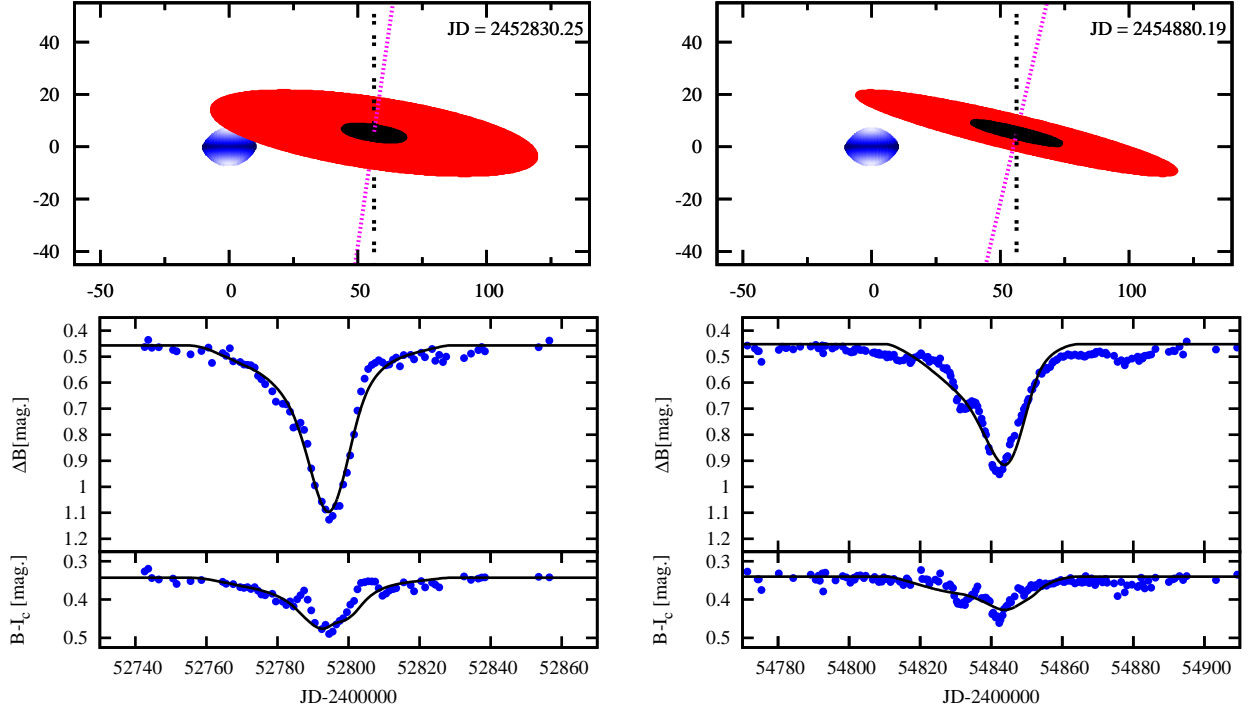


Fig. 14. Modelling of the eclipses of a rapidly rotating Be star by a solid disk, considering both the 2003 (*left*) and 2008/9 (*right*) eclipses. The precession period is a free parameter. The top panels show projections of the system onto the plane of the sky. The polar (hot) and equatorial (cool) areas of the star are shown by changing shades. The inner (opaque) and outer (semi-transparent) areas of the disk are shown by dark and light shades, respectively. The sizes are expressed in solar radii. The lower panels show the B light curve (*middle*) and the $B - I_C$ colour index (*bottom*) together with the synthetic fits (lines). The Julian day in the upper right corner represents the moment at which (according to the model) the spatial configuration of the system is the same as shown in the relevant panel.

tric gap (or a local, concentric depression of the density) or (ii) a central opening in the disk structure. The former would be adequate for eclipse models similar to those presented here, i.e. in which the impact parameter is small enough for both sides of the entire disk to be involved in the eclipses. The latter would require the impact parameter to be larger, so that the eclipses could be caused by about half of the disk. Which of these two cases is true? We are unable to establish this based on the photometric observations. The behaviour of the Na I sodium doublet lines suggests that case (ii) may be correct. In this case, the disk would be about twice as large as in case (i) and it would move on an orbit with an appropriately higher speed.

4.3. Precession solutions from the 2003 and 2008/9 eclipses

As stated above, we propose that the precession of the disk is responsible for the observed differences between the eclipses from epoch to epoch. Since the number of eclipses observed is small, the constraints on precession are weak, so other processes, perhaps connected with changes in the disk size and/or its internal structure, might be needed to explain the rapid changes. Nevertheless, we decided to study our hypothesis of precession as the most likely hypothesis that can presently be constrained.

In one approach, we used the highest quality photometric data obtained during the last two eclipses, when the disk was nearly edge-on, so that its optical thickness was high, but it projected to a small solid angle at that time. Using our code, we determined the best-fit solution for the solid disk for the two last eclipses, taking precession into account. The basic assumptions

about the nature of the Be star, and the both fixed and free parameters were the same as those in Section 4.1. The disk was treated as having negligible thickness (infinitesimally small with all its mass concentrated in the plane) with an r^{-2} density profile. The precession period of the disk P_{prec} was adopted as an additional free parameter. For simplicity, the precession axis was assumed to be perpendicular to the orbital plane. The resulting model is presented in Fig. 14 and its parameters are shown in Table 3. The best-fit solution was obtained for the precession period $P_{\text{prec}} \approx 61.94$ yr (about $11 P_{\text{orb}}$) for which the angle related to the disk precession phase ϕ_d changes from 34.88° at epoch $E = 9$ to 67.5° at epoch $E = 10$. Such a fast precession seems to be necessary to explain the observed rapid changes in the eclipse depths at consecutive epochs. For example, the very shallow eclipse at $E = 3$ occurred very close in time to two very deep eclipses at $E = 2$ and $E = 4$, and the deep minimum at $E = 8$ was followed by two shallow ones at $E = 9$ and $E = 10$. An alternative solution exists according to which the disk would achieve, at epoch $E = 10$, the precession phase $\phi_d = 112.5^\circ$ with about half the precession period of the former solution, $P_{\text{prec}} \approx 26.03$ yr ($\sim 5 P_{\text{orb}}$). Since we are only able to observe a projection of the disk, we are unable to distinguish between these two cases using only the photometric data of these two eclipses.

4.4. Precession solutions using all the eclipses

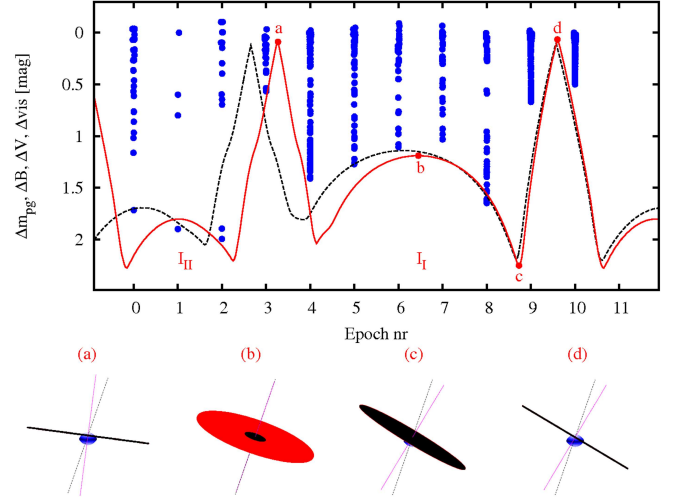
However, although the precession period in EE Cep should indeed be rather short, its lower limit of about five orbital periods inferred from colour variations during two successive eclipses,

Table 3. Parameters obtained from the solution of the solid disk model when applied to the last two eclipses together, taking into account disk precession.

Parameter	Value	\pm	Unit
D	4.91	0.15	R_{\odot}
$T_{0(E=9)}$	52795.25	0.27	day
$T_{0(E=10)}$	54845.19	—	day
V_t	1.78	0.12	R_{\odot}/day
θ_d	14.39	2.59	degree
$\phi_d(E=9)$	34.88	2.63	degree
$\phi_d(E=10)$	67.50	—	degree
P_{prec}	61.94	1.66	yr
κ_s	0.175	0.019	1
ρ_c	92.8	11.2	$1 R_{\odot}^{-3}$

as presented in Section 4.3, seems unrealistic. One credible argument for a longer period of precession is the following, which favours a P_{prec} of the order of $14P_{\text{orb}}$ (≈ 78.5 yr). If the shallow minimum with a flat bottom observed in 1969 was indeed caused by an edge-on, non-tilted disk (Mikołajewski & Graczyk 1999), then the precession axis is not perpendicular to the orbital plane. For perpendicular orientations, two edge-on positions with opposite tilt angles should be observed. More generally, two edge-on positions can occur when the precession axis lies nearly in the sky plane and is inclined with respect to the orbital plane. One of these positions may be non-tilted with respect to the orbital motion, but both should produce similar (shallow) eclipse depths, despite the very different tilt angles, because an edge-on disk obscures at most only a small part of the Be star. This situation might have arisen in 1969 ($E = 3$) and 2008/9 ($E = 10$), if the time interval between these minima was about half a precession period. This hypothesis provides a solution what may satisfy the data of all the eclipses. Thus, we propose this as a possible way of explaining the seemingly chaotic changes that occur in successive eclipses. The next key step in understanding this system was to realize that the deepest eclipses are not necessarily those that occur when the projected disk size is greatest (as we assumed at first); the deepest eclipses must instead be those where the column density in the disk and the projected disk size are together high enough to obscure most of the Be star surface. This situation must occur close in time to the most shallow eclipses in order to be consistent with the rapid changes in the eclipse depths. According to this line of reasoning, during the shallowest eclipses, the projection of the disk becomes small so that there is very little obscuration of the stellar flux, even though the column density in the disk is greatest at that time. Similarly, the eclipses should have intermediate depths at those precession phases at which the projected disk size is largest, since, despite the eclipsing of nearly the whole surface of the star, this eclipsing is performed by the highly transparent part of the disk.

We tested this hypothesis using our numerical code for the case with a precession axis inclined relative to the normal of the orbital plane by several different small values of θ_{prec} . We found that as a first approximation, ϕ_{prec} should be around 70° – 80° (see Fig. 12 for the definition of θ_{prec} and ϕ_{prec}). When θ_{prec} is non-zero (i.e. the precession axis is inclined), the value of ϕ_{prec} determines how unequal the time intervals between the two shallowest minima in the precession cycle will be and how different the eclipse depths will be between these two intervals. We define I_I as the time interval from the eclipse with the minimal tilt of the projected disk (as in 1969) to the eclipse with a maximal disk tilt (as in 2008/9) and vice versa, I_{II} as the time interval from the eclipse with maximal disk tilt to the eclipse with minimal disk

**Fig. 15.** Dependence of the depths of eclipses in EE Cep system on precession. Photometry obtained during epochs 0–10 is shown as circular symbols. The solid and dashed lines delineate two models of the changes in eclipse depth as a function of orbital phase, generated using our numerical code. In these two cases, the precession periods P_{prec} are $10.8P_{\text{orb}}$ and $11.8P_{\text{orb}}$, respectively. At the bottom, the spatial configurations of the disk and the star in four special cases, denoted by the letters a, b, c, and d, are shown.**Table 4.** Subjective (“eye”) and quantitative (“fit”) optimal solutions of our precession model using all the eclipses.

Parameter	eye	fit	\pm	Unit
R_{d0}	75.0	73.8	2.7	R_{\odot}
H	1.0	0.6	...	R_{\odot}
D	4.0	4.0	...	R_{\odot}
T_0	40493.92	40493.92	...	day
V_t	2.0	2.0	...	R_{\odot}/day
θ_d	12.5	12.1	0.7	degree
ϕ_d^*	175.0	173.7	1.9	degree
θ_{prec}	18.0	19.5	1.0	degree
ϕ_{prec}	79.0	80.0	2.0	degree
P_{prec}	11.8	10.8	0.4	P_{orb}
κ_s	0.328	0.328	...	1
ρ_c	1.18	1.13	1.21	$1 R_{\odot}^{-3}$
n^{**}	0.3	0.27	0.09	1

Notes. (*) At the time of minimal disk tilt.

(**) Exponent in the function describing the disk density distribution.

tilt. When $\phi_{\text{prec}} = 90^\circ$, the time intervals I_I and I_{II} are equal and the changes in eclipse depth as a function of precession phase proceed symmetrically with respect to the times of the shallowest eclipses. In general, however, ϕ_{prec} differs from 90° , in which case asymmetry appears. For example, when $\phi_{\text{prec}} < 90^\circ$, the time interval I_{II} is shorter than I_I and the eclipses during I_{II} are deeper, especially during the central parts of this interval. This seems to be the case for EE Cep. We know that $I_I \sim 7P_{\text{orb}}$ and that I_{II} seems to be shorter. Hence, if this scenario were correct, we would have succeeded in constraining the full precession period $P_{\text{prec}} \lesssim 14P_{\text{orb}}$.

We considered many combinations of sets of parameters, for different disk sizes, starting from the large ($R_{d0} \sim 200 R_{\odot}$) and geometrically thick ($H \sim R_p$) disks. Because the adopted artifi-

cial density distribution does not provide a good solution for the external parts of the light curves during the eclipses, we concentrated on their central parts, i.e. we searched for the set of parameters that could explain the dependence of eclipse depth on precession phase. By visual inspection of plots comparing the synthetic curves that represent the dependence of the eclipse depth on precession with the observational data, we chose subjectively a few optimal sets of parameters. One of these fits, perhaps the best of them, is shown in Table 4 (left) and Fig. 15 (dashed line). Using the simplex algorithm, we performed a χ^2 minimization over the parameter space of the system input parameters. The best-fit solution is that shown in Table 4 (right) and the synthetic fit is presented as the solid line in Fig. 15. Our solutions were obtained for a disk radius $R_{d0} \approx 75R_{\odot}$ and a geometrically very thin disk $H = 0.6R_{\odot}$. We cannot exclude, however, the possibility that a smaller or larger disk could provide more reliable results. On the other hand, the disk thickness in the optimal solution equals the spatial resolution adopted in the model (which represents the grid size) and in reality, the disk could be even thinner. The disk must be extremely thin in order for this model to work correctly at times close to the shallow minima. Some of the eclipses in the EE Cep system could be even shallower than those in 2008/9 (the disk could sometimes almost completely disappear, as happens with Saturn’s rings when they have an edge-on orientation).

Thus, our model (Table 4) suggests that the value of the precession period should be about 11–12 P_{orb} . Is it possible that the precession period is really so short? The development of a mechanical model of a precessing circumstellar disk would be a useful follow-up study to this paper to test our preferred solution theoretically. Empirically, at least one binary system that appears to have a similarly short precession period exists. This system, SS433, is very different from EE Cep – it is far more compact and the disk has to be smaller and perhaps more massive. Margon et al. (1980) suggested that the SS433 system, with $P_{\text{orb}} \approx 13^{\text{d}}$, has an accretion disk that can precess with a period of 164^{d} , which is just 12.5 times its orbital period.

Applying our model of precession to predict the depth of the next EE Cep minimum, we find that it should be similar to the deepest of the previous eclipses, reaching about 2^{m} . According to the ephemeris (Eq. 1), this minimum should occur on 23 Aug 2014. To some degree, this tests our proposed model, although this model has a serious problem. The existing set of observations span a time interval that is almost identical to the expected precession period. A statistically more significant test would require much more than one full precession cycle, and preferably at least two cycles. Several more decades of observations would be required. Nevertheless, there is some hope that old photographic surveys might contain a sufficient amount of extra data. For example, the database of the DASCH³ (Digital Access to a Sky Century @ Harvard) project (see Grindlay et al. 2009) provides data from more than 5000 old Harvard photographic plates obtained between JD 2411556 and JD 2447823 (nearly exactly 100 years) that contain EE Cep in their field of view. By checking the Julian dates when these photographs were obtained using EE Cep’s ephemeris, it seems likely that we may be able to extract data for the eclipses from epochs $E = -9$ to $E = -1$, with which we can test our model.

4.5. On the similarity of EE Cep and ε Aur

Our observations show that the disk in the EE Cep system may be similar to (though smaller than) the multi-ring structure observed in ε Aurigae. Leadbeater & Stencel (2010) found that the equivalent width of the K I potassium line at 7699 Å increased step-wise during the ingress of the last ε Aur eclipse. They interpreted this pattern as a manifestation of the complex structure of the disk as an alternating series of concentric rings and gaps, which had already been suggested based on the observations of the previous eclipse during the 1980’s (Ferluga 1990). According to what until recently has been the dominant interpretation, based on ε Aur observations during the eclipse of the 1980’s, a quite close binary system should exist at the disk centre (Lissauer & Backman 1984). On the basis of their spectral energy distribution (SED) analysis, Hoard et al. (2010) suggested that the ε Aur system is composed of a massive B5V type primary embedded in a dusty disk with a radius of about 3.8 AU and an F type post-AGB secondary of about half the mass of the primary. In this model, the disk has to be a byproduct of mass transfer from the initially more massive star (currently an F type post-AGB) to what was initially the secondary (and is now a more massive B5V star). Kloppenborg et al. (2010), via interferometric observations during the ingress of the 2009 eclipse, detected and measured movement of the disk with respect to the F star. They confirmed the existence of an optically thick, inclined disk in the system and provided the first direct evidence that the disk is geometrically thin. The mass of the disk is dynamically negligible ($\lesssim 15 M_{\oplus}$), but is sufficient to cause eclipses. Hoard et al. (2010) pointed out that the dust content of the disk must be largely confined to grains larger than $\sim 10 \mu\text{m}$ to explain the grey nature of eclipses, from the optical range up to the infrared, and the lack of broad dust emission features in the mid-infrared spectra. Owing to the important role that grey extinction plays in our models, we can conclude that the disk in the EE Cep system should also be dominated by particles of quite large diameters – a mixture of grains and dust, and our results concerning our precession model also suggest that this disk should be geometrically very thin.

In both cases, ε Aur and EE Cep, the disks are inclined to the orbital plane. The presence of a binary system at the disk centre might help to explain the inclination of the disk and the rapid precession. However, the statistical likelihood of a binary system at the centre of the disk in the case of ε Aur is low, and for EE Cep even lower. Another possible way of explaining the inclination of the disk is that since the main component in EE Cep is a rapidly rotating Be star, it is very probable that it is the donor star that supports a disk around its companion. Therefore, to explain the inclination of this disk relative to the orbit, we have to assume that the orbital plane is not coplanar with the equatorial plane of the Be star. In this case, the disk around the companion will also not be coplanar with the orbit. In principle, to introduce disk precession into the system in a way in which the precession axis is inclined to the orbital plane, it is sufficient to add a third body as the perturber if it satisfies two conditions: (i) its orbit should not be coplanar with the orbital plane of the disk, and (ii) it should have a high enough mass (and/or the disk should have a low enough mass). In the light of these two conditions, we have many possibilities as to what could constitute a third body. It could be an object orbiting the Be star, either closer to or further away from than the eclipsing object, but it might also be an object on an orbit around the body at the disk centre, either outside or within the disk. The latter case would be equivalent to the presence of a binary system at the disk centre. At the moment,

³ <http://hea-www.harvard.edu/DASCH/>

we probably do not have enough observations of the system to decide which of these possibilities is most likely to be correct.

In addition to the differences in the sizes of the systems, there are additional indications that the geometries of the eclipses could be very different. While the consecutive eclipses in ε Aur are nearly identical in terms of their depth (see eg. Stencel 2009), the eclipse depths in EE Cep are highly variable. Some variations in the durations of the entire eclipse and the various stages of the eclipse (ingress, totality, and egress) in ε Aur (see Hopkins & Stencel 2008) are observed. Perhaps these changes could be explained in terms of disk precession. In this case, the large differences between the eclipse depths of EE Cep and ε Aur would be explained by variations in the direction of the rotation axis due to the strong precession in the case of EE Cep and a small θ_{prec} (of Fig.12 caption) in ε Aur. There are also interesting differences between the Na I doublet line profiles observed during the eclipses of these systems. During the last eclipse of ε Aur, an additional component appeared, which was redshifted during the first part of the eclipse and blueshifted during the second part (see Tomov et al. 2012), in contrast to EE Cep, where only blueshifted additional components were observed. This may indicate that in the case of EE Cep, the impact parameter may be so large that roughly only half of the disk is involved in the eclipses.

5. Conclusions

We have presented our observational data obtained during the last three eclipses of EE Cep. We release these data for use by the astronomical community. For the two latest minima, our investigations were carried out as international campaigns that provided data of unprecedented quality for this object, especially in the case of the photometry, where an accuracy of a few thousandths of a magnitude was achieved. These minima turned out to be the shallowest EE Cep eclipses observed. The grey character of these eclipses, i.e. the weak dependence of the eclipses' depth on the photometric band, reinforces our belief that the eclipsing object is indeed a dark, dusty debris-disk around a low-luminosity central body that is visible in neither the spectra nor photometry.

The results of these campaigns shed new light on our understanding of the EE Cep system. Our spectroscopic data have demonstrated that the main component of the system is a rapidly rotating ($v \sin i \approx 350 \text{ km s}^{-1}$) Be-type star. The oblateness of the star leads, via the von Zeipel effect, to a highly inhomogeneous temperature distribution across its surface. The spectra obtained during the last two eclipses suggest that the absorption lines change in the same way during each eclipse. During the minima of both eclipses, we were able to detect at least three absorption components in the Na I lines and the same strong absorption superimposed on the H α emission.

By analysing all the photometric and spectroscopic data together, we have proposed several hypotheses that provide predictions for future eclipses.

Using high quality photometry, it was possible to detect two blue maxima in the colour indices during the 2003 and 2008/9 eclipses, that occurred from about six to nine days before and after the photometric minimum. The first (stronger) blue maximum occurred simultaneously with a “bump” in the light curves, which is very clear in all the $UBV(RI)_C$ photometric bands. This “bump” seems to be caused by a temporal offset between the two minima in a single eclipse, which can be explained by the non-simultaneous obscuration of the hot polar regions of the Be star by the elliptical, tilted shape of the projected disk.

The durations of the last two eclipses were longer than expected (both lasting about 90 days). In the external parts of these long minima, two shallow minima were observed about 35 days before and after mid-eclipse during both epochs (arrows in Fig. 10). This could be explained by the presence of a gap near the outer border of the disk. The second blue maximum, which could not be explained by the mechanism proposed for the “bump”, may indicate the existence of either an inner gap or a central opening. Thus, the disk in the EE Cep system could have a complex, possibly multi-ring structure. The behaviour of the Na I line profiles gives some support to this idea. Another hypothesis that follows from the behaviour of these lines and the recurrent asymmetry of the eclipses is that maybe only half the disk is involved in the eclipses.

Considering all the eclipses together, from the 1950's to the present, we estimated the duration of the disk precession period to be about 62–67 years ($\sim 11\text{--}12 P_{\text{orb}}$). Using our new model of precession, we predict that the depth of the forthcoming eclipse in 2014 should be one of its deepest, reaching about 2^{m} .

More spectroscopic observations during the next eclipse would be needed to more clearly understand the nature of the EE Cep system. Photometry in the infrared JHK bands during and after the eclipse would be very useful. This could make it possible to detect the secondary companion of EE Cep (disk and/or central star/stars), as it seems to make a significant contribution to the total flux at the red edge of the visible spectrum (a brightening event by about $0^{\text{m}}.05$ at the phase ~ 0.2 was observed). The radial velocity variations of the hot component, which would be a real challenge to obtain, may be of crucial importance in constraining the parameters of this system.

Acknowledgements. E. Semkov would like to thank the Director of Skinakas Observatory, Prof. I. Papamastorakis, and Dr. I. Papadakis for granting telescope time. We thank T. Karmo, Stefan Mochnacki, and G. Conidis for contributing their data. Some of the observations used here were taken courtesy of the AAVSO and the Sonoita Research Observatory. This study was supported by MNiSW grant No. N203 018 32/2338.

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Appendix A: The models of eclipses with a solid or a gapped disk

Using our numerical code, we fitted models of the last two eclipses separately, using a solid disk as the eclipsing object. We made the same assumptions about the nature of the Be star, and we used the same fixed and free parameters as in Section 4.1. The disk was treated as having negligible thickness (infinitesimally small with all the mass concentrated in the plane) and an r^{-2} density profile. For simplicity, the precession axis was assumed to be perpendicular to the orbital plane. The resulting solution is shown in Table A.1 together with the error estimates. In Fig. A.1, we present models of two eclipses using a solid disk, for the 2003 eclipse on the left and for the 2008/9 eclipse on the right. The models containing a solid disk provide quite a good fit to the light curve and the global colour changes, reproducing both the depth and the shape of the eclipses, especially for the 2003 eclipse. This model, however, cannot explain the two maxima in the colour evolution during the eclipses.

In the present study, we adopted a model containing a disk that has a concentric gap for the two last eclipses, taking into account the precession of the disk. We assumed the same disk diameter, disk density distribution, and orthogonality of the precession axis to the orbital plane, and the same Be star parameters as in the case of the solid disk. This model was based solely on the $B - I_C$, $V - I_C$, and $V - R_C$ colour indices. We chose the same free parameters as in the case of the solid disk model for the 2008/9 eclipse (the tangential velocity was fixed at $V_t = 1.57 R_\odot \text{day}^{-1}$) but added three more free parameters: the precession period P_{prec} and two parameters specifying the outer R_{d1} and inner R_{d2} radii of the gap. The resulting model is presented in Fig. A.2 and Table A.2. The best results were obtained for the precession period $P_{\text{prec}} \approx 31.91 \text{yr}$ (about $5-6 P_{\text{orb}}$), for which the angle related to the disk precession phase ϕ_d changes from 50.00° at epoch $E=9$ to 113.32° at epoch $E=10$. An alternative solution was found to exist in which the precession phase $\phi_d = 66.68^\circ$ at epoch $E=10$ has a precession period $P_{\text{prec}} \approx 121.13 \text{yr}$, which is almost four times longer (being about $22 P_{\text{orb}}$). In the light of the results of Sections 4.3 and 4.4, both these periods of precession seem to be unrealistic. Comparison of this model with the Gałan et al. (2008) model for the 2003 eclipse alone reveals a problem. The gapped disk model seemed to be very promising for explaining the colour changes that occurred during the 2003 eclipse, but fails in the case of the 2008/9 eclipse, since it cannot explain either the colour changes during an eclipse or the strong “bump” in the light curve.

Table A.1. The parameters of the solutions obtained for the solid disk model, derived independently for the 2003 eclipse (left) and the 2008/9 eclipse (right).

Parameter	2003 eclipse	\pm	2008/9 eclipse	\pm	Unit
D	4.74	0.24	6.32	0.59	R_\odot
T_0	52795.98	0.29	54843.85	0.50	day
V_t	1.57	0.06	1.57*	...	R_\odot/day
θ_d	20.05	0.93	16.36	2.05	degree
ϕ_d	52.85	1.28	27.32	2.00	degree
κ_s	0.171	0.022	0.346	0.034	1
ρ_c	94.8	8.6	45.5	3.9	$1 R_\odot^{-3}$

* For the 2008/9 eclipse model the tangential velocity V_t was adopted to be identical to that obtained for the 2003 eclipse.

Table A.2. Parameters of the solution of the gapped disk model when applied to the last two eclipses together, taking into account disk precession.

Parameter	Value	\pm	Unit
R_{d1}	27.61	0.85	R_\odot
R_{d2}	14.19	0.46	R_\odot
D	6.97	0.37	R_\odot
$T_{0(E=9)}$	52797.07	0.48	day
$T_{0(E=10)}$	54847.01	—	day
V_t	1.57*	...	R_\odot/day
θ_d	21.48	0.47	degree
$\phi_d(E=9)$	50.00	1.92	degree
$\phi_d(E=10)$	113.32	—	degree
P_{prec}	31.91	1.14	yr
κ_s	0.056	0.014	1
ρ_c	113.6	5.9	$1 R_\odot^{-3}$

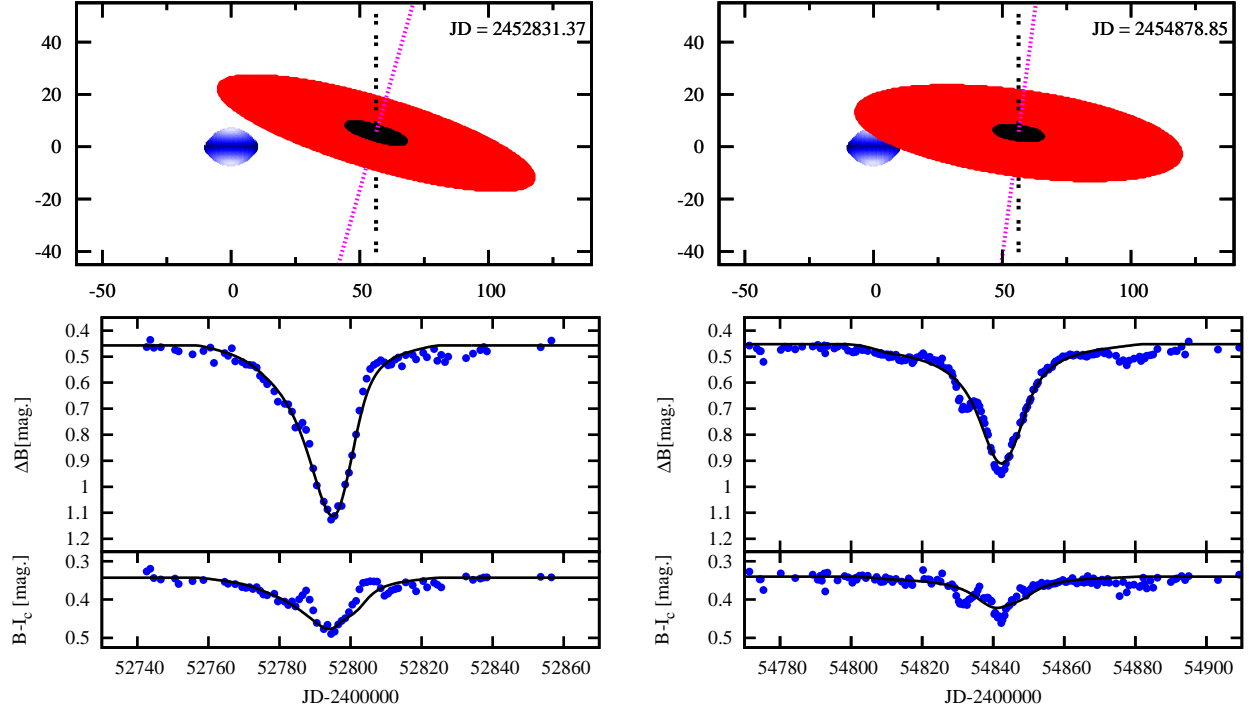


Fig. A.1. Modelling of the eclipse of a rapidly rotating Be star as a solid disk during the 2003 eclipse (*left*) and the 2008/9 eclipse (*right*). The top panels show the system projected onto the plane of the sky. The polar (hot) and equatorial (cool) areas of the star are shown by different shades. The inner (opaque) and outer (semi-transparent) areas of the disk are shown by dark and light shades, respectively. The sizes are expressed in solar radii. The lower panels show the B light curve (*middle*) and the $B - I_C$ colour index (*bottom*) together with the synthetic fits (lines). The Julian day in the upper right corner represents a moment at which (according to the model) the spatial configuration of the system is the same as that shown in the relevant panel.

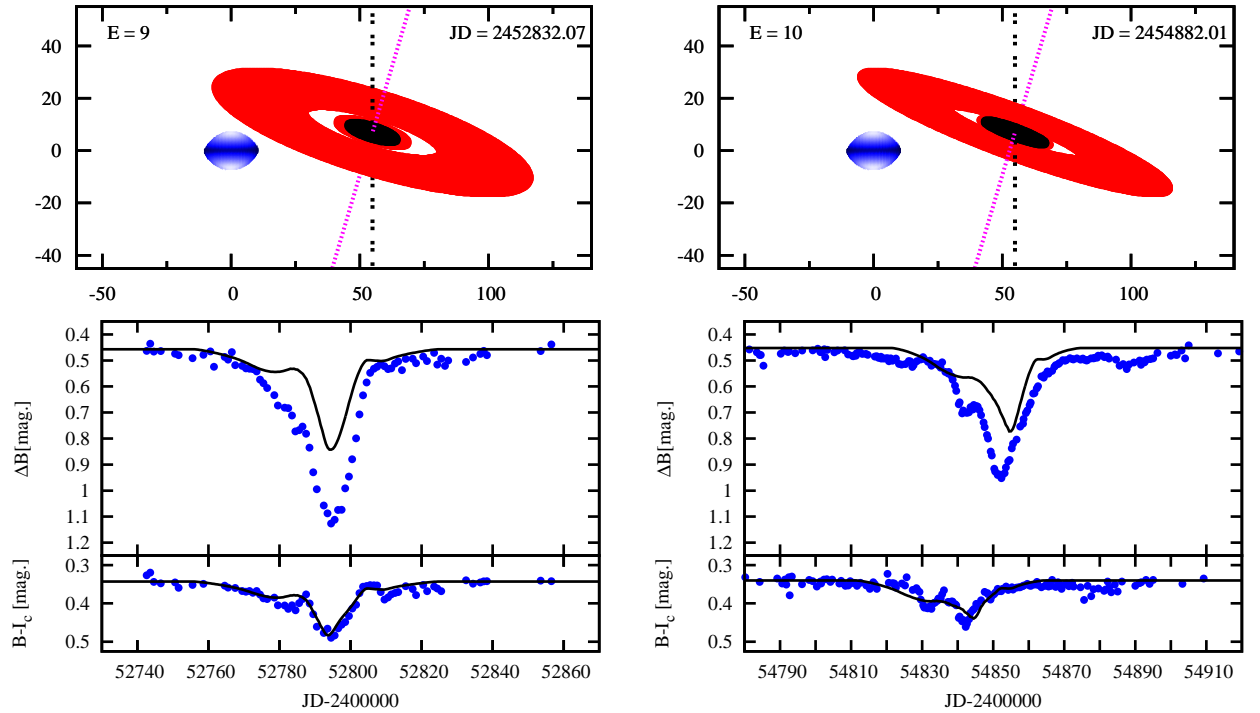


Fig. A.2. Modelling of the last two eclipses together with the precession period taken as an additional free parameter, when a gapped disk is considered. The sky plane projections of the system during the last two eclipses (at $E = 9$ and $E = 10$) (*top*), the B light curve (*middle*), and the $B - I_C$ colour index (*bottom*), together with the synthetic fits (lines) are shown. The symbols and the shades of colour have the same meaning as those in Fig. A.1.

Appendix B: Online photometric and spectroscopic data

Table B.1. Photometry in standard $UBVR_C$ filters and a non-standard i ($\bar{\lambda}_i \approx 7420 \text{ \AA}$) filter obtained at Piwnice Observatory* (Poland) during and near the 1997 eclipse ($E = 8$). A one-channel photometer with an uncooled EMI 9558B photomultiplier on the 0.6 m Cassegrain telescope was used. The differential magnitudes are given with respect to our standard star BD +55°2690, together with the corresponding standard deviations.

JD	ΔU	ΔB	ΔV	ΔR_C	Δi	σ_U	σ_B	σ_V	σ_{R_C}	σ_i
2450348.616	0.050	0.450	0.415	0.310	0.243	0.025	0.025	0.015	0.009	0.054
2450349.618	0.040	0.481	0.414	0.320	0.268	0.026	0.024	0.014	0.009	0.043
2450360.540	0.045	0.426	0.392	0.298	0.350	0.032	0.022	0.011	0.016	0.055
2450474.366	0.176	0.515	0.407	0.225	0.132	0.081	0.055	0.031	0.026	0.041
2450512.336	-0.034	0.239	0.205	0.196	0.132	0.139	0.104	0.075	0.077	0.119
2450711.327	0.122	0.506	0.441	0.331	0.322	0.033	0.017	0.010	0.008	0.056
2450712.606	0.177	0.461	0.437	0.345	0.274	0.028	0.016	0.007	0.008	0.022
2450720.565	0.174	0.585	0.527	0.441	0.302	0.040	0.030	0.030	0.030	0.040
2450742.436	1.682	2.089	1.948	1.791	1.589	0.035	0.025	0.018	0.017	0.040
2450743.298	1.785	2.107	2.013	1.765	1.727	0.035	0.024	0.015	0.009	0.035
2450746.393	1.675	1.988	1.874	1.651	1.572	0.035	0.022	0.012	0.007	0.020
2450747.421	1.563	1.807	1.700	1.557	1.401	0.035	0.018	0.008	0.011	0.041
2450748.364	1.396	1.730	1.650	1.463	1.359	0.044	0.020	0.010	0.012	0.039
2450749.339	1.205	1.613	1.524	1.346	1.153	0.045	0.028	0.016	0.009	0.025
2450750.329	1.201	1.476	1.406	1.271	1.180	0.031	0.024	0.020	0.017	0.042
2450756.203	0.436	0.695	0.674	0.559	0.461	0.023	0.023	0.016	0.017	0.027
2450756.511	0.299	0.684	0.624	0.522	0.454	0.027	0.013	0.010	0.008	0.022
2450757.202	0.398	0.620	0.588	0.509	0.409	0.021	0.015	0.012	0.010	0.031
2450757.519	0.269	0.631	0.591	0.485	0.375	0.022	0.010	0.007	0.008	0.015
2450763.209	0.375	0.624	0.452	0.313	0.153	0.050	0.040	0.030	0.020	0.050
2450798.300	0.142	0.556	0.498	0.361	0.338	0.028	0.028	0.016	0.012	0.023
2450819.339	0.109	0.447	0.396	0.288	0.190	0.028	0.019	0.009	0.010	0.020
2450825.516	0.063	0.462	0.396	0.307	0.167	0.033	0.013	0.010	0.009	0.026
2450826.201	0.063	0.467	0.408	0.312	0.218	0.035	0.015	0.012	0.010	0.021
2450837.216	0.109	0.465	0.410	0.290	0.256	0.024	0.015	0.012	0.015	0.030
2450839.386	0.086	0.428	0.390	0.276	0.230	0.045	0.030	0.009	0.008	0.004
2450843.266	0.079	0.469	0.415	0.310	0.209	0.014	0.015	0.008	0.008	0.022
2450845.397	0.142	0.434	0.401	0.314	0.260	0.042	0.019	0.008	0.009	0.024
2450954.455	0.085	0.435	0.398	0.309	0.206	0.042	0.018	0.011	0.005	0.020
2450985.472	0.009	0.395	0.375	0.242	0.190	0.026	0.012	0.017	0.027	0.018
2451029.502	0.195	0.452	0.347	0.306	0.159	0.040	0.025	0.016	0.016	0.067
2451077.352	0.171	0.495	0.399	0.330	0.214	0.047	0.011	0.015	0.014	0.027
2451078.470	0.075	0.465	0.402	0.292	0.231	0.025	0.012	0.015	0.010	0.029
2451093.412	0.085	0.450	0.414	0.340	0.245	0.022	0.026	0.014	0.016	0.022
2451105.418	0.101	0.447	0.409	0.293	0.187	0.010	0.009	0.010	0.005	0.011
2451196.285	0.109	0.435	0.398	0.283	0.220	0.019	0.013	0.010	0.006	0.019
2451332.418	0.090	0.476	0.389	0.290	0.057	0.040	0.019	0.009	0.011	0.032
2451435.577	0.118	0.464	0.424	0.310	0.116	0.020	0.011	0.008	0.006	0.029

* Observers: D. Graczyk, J. Janowski, M. Mikołajewski.

Table B.2. Photometry obtained at Athens Observatory* (Greece) with standard $BV(RI)_C$ (Bessell) filters during and near the 2003 eclipse ($E = 9$). The 0.4 m Cassegrain telescope with an SBIG ST8 CCD camera was used. Differential magnitudes are given with respect to BD +55°2690. Each point is the mean value obtained from several to tens of frames. The columns labelled $HJD+$ denote the fraction of the day.

HJD	$HJD+$	ΔB	$HJD+$	ΔV	$HJD+$	ΔR_C	$HJD+$	ΔI_C
2452739	.62750	0.488	.62337	0.437	.62475	0.316	.62541	0.144
2452764	.64212	0.522	.64044	0.464	.64775	0.336	.64316	0.166
2452765	.53587	0.529	.54065	0.472	.54330	0.342	.54433	0.172
2452769	.49517	0.555	.49336	0.490	.48959	0.357	.49209	0.186
2452770	.56873	0.564	.57578	0.491	.57405	0.363	.57508	0.193
2452771	.55519	0.566	.54796	0.499	.54933	0.376	.55270	0.197
2452772	.53586	0.567	.54233	0.511	.46700	0.369	.52149	0.193
2452773	.56504	0.576	.57164	0.509	.56991	0.381	.57401	0.207
2452774	.50343	0.584	.50238	0.532	.50405	0.388	.49545	0.218
2452775	.47683	0.621	.47800	0.542	.48459	0.417	.47315	0.233
2452776	.47378	0.636	.47824	0.561	.47607	0.430	.48915	0.246
2452781	.45747	0.715	.46881	0.636	.47640	0.486	.47743	0.308
2452786	.47119	0.788	.49102	0.714	.49241	0.577	.49783	0.398
2452788	.46608	0.852	.46946	0.795	.46176	0.654	.46171	0.463
2452792	.42979	1.068	.44118	0.988	.44256	0.825	.44825	0.611
2452793	.57410	1.141	.57307	1.033	.57445	0.868	.57859	0.651
2452794	.51185	1.160	.51545	1.065	.51156	0.894	.53862	0.678
2452795	.53744	1.165	.54773	1.046	.54494	0.882	.54615	0.675
2452800	.42771	0.901	.42606	0.836	.43365	0.695	.42845	0.507
2452801	.53422	0.823	.53600	0.752	.53604	0.614	.54151	0.435
2452802	.40815	0.732	.41125	0.674	.41528	0.540	.43071	0.359
2452803	.44077	0.671	.44744	0.600	.44330	0.465	.44978	0.305
2452804	.45837	0.612	.46491	0.555	.46056	0.438	.46753	0.263
2452805	.56707	0.577	.57346	0.510	.57175	0.393	.57591	0.220
2452806	.57030	0.567	.57443	0.503	.57952	0.377	.57786	0.208
2452807	.53823	0.576	.54110	0.487	.54125	0.375	.54398	0.196
2452808	.53893	0.572	.53822	0.482	.53939	0.370	.53724	0.184
2452809	.57845	0.565	.57985	0.470	.57969	0.362	.57967	0.174
2452810	.54475	0.567	.54468	0.474	.55963	0.371	.54444	0.181
2452811	.42696	0.564	.42732	0.469	.42716	0.370	.42753	0.186
2452812	.53275	0.556	.53775	0.479	.54214	0.359	.52927	0.178
2452813	.38111	0.551	.38625	0.473	.38870	0.358	.38856	0.172
2452814	.47151	0.571	.47200	0.477	.47231	0.370	.47257	0.168

* Observers: K. Gazeas, P. Niarchos.

Table B.3. Photometry in standard VI_C filters and wide $H\alpha^W$ and narrow $H\alpha^N$ filters (FWHM ≈ 200 Å and 30 Å, respectively) obtained at Białków Observatory* (Poland) during and near the 2003 eclipse ($E = 9$). The 0.6 m Cassegrain telescope with a Photometrics Star I CCD camera was used. Differential magnitudes are given with respect to BD +55°2690. The columns labelled $HJD+$ denote the fraction of the day.

HJD	$HJD+$	ΔV	$HJD+$	ΔI_C	$HJD+$	$\Delta H\alpha^W*$	$HJD+$	$\Delta H\alpha^N*$
2452776	.5778	0.518	.5743	0.223	.5810	0.208	.5807	-0.390
2452777	.5320	0.531	.5175	0.244	.5503	0.222	.5555	-0.426
2452784	.5616	0.662	.5487	0.354	.5598	0.350	.5598	-0.301
2452788	.5578	0.754	.5582	0.438	.5592	0.421	.5592	-0.227
2452790	.5551	0.885	.5540	0.545	.5549	0.524	.5546	-0.175
2452793	.5550	0.983	.5533	0.624	.5562	0.600	.5565	-0.137
2452795	.5448	0.995	.5345	0.641	.5449	0.601	.5488	-0.166
2452798	.5410	0.887	.5431	0.552	.5420	0.524	.5423	-0.205
2452800	.5436	0.804	.5471	0.469	.5542	0.481	.5583	-0.237
2452837	.5224	0.427	.5243	0.128	.5312	0.118	.5308	-0.473
2452840	...	...	...	...	.4921	0.125	.4921	-0.511
2452841	.4810	0.419	.4777	0.123	.4883	0.111	.4881	-0.500
2452872	.4676	0.425	.4652	0.129	.4732	0.091	.4731	-0.572
2452885	.6077	0.424	.6058	0.121	.6110	0.084	.6109	-0.597
2452887	.6238	0.422	.6238	0.119	.6238	0.090	.6238	-0.617
2452888	.6174	0.412	.6146	0.110	.6236	0.098	.6236	-0.637
2452889	.6265	0.416	.6287	0.117	.6390	0.089	.6386	-0.606

* Observers: Z. Kołaczowski, G. Michalska, A. Pigulski

Table B.4. $UBV(RI)_C$ photometry obtained at Kraków Observatory* (Poland) during and near the 2003 eclipse ($E = 9$). The 0.5 m Cassegrain telescope with a Photometrics CH350 CCD camera was used. Differential magnitudes are given with respect to BD +55°2690. Each point is the mean value obtained from several to tens of frames. The columns labelled $HJD+$ denote the fraction of the day.

HJD	$HJD+$	ΔU	$HJD+$	ΔB	$HJD+$	ΔV	$HJD+$	ΔR_C	$HJD+$	ΔI_C
2452742	...	...	.61300	0.463	.61483	0.423	.61444	0.310	.61482	0.136
2452743	...	...	.61000	0.436	.60964	0.423	.60846	0.308	.60989	0.116
2452744	.61238	0.095	.59863	0.466	.59958	0.443	.59856	0.335	.60249	0.122
2452746	.58829	0.107	.59760	0.451	.59757	0.423	.59779	0.301	.59065	0.109
2452750	.60107	0.119	.58647	0.474	.59057	0.440	.58976	0.326	.59308	0.129
2452751	.60010	0.092	.59110	0.480	.59252	0.449	.59116	0.333	.59189	0.120
2452755	.58115	0.133	.58724	0.491	.58649	0.460	.58530	0.347	.58756	0.123
2452758	...	...	.58841	0.478	.58998	0.443	.58900	0.323	.58976	0.129
2452764	.54462	0.124	.54941	0.485	.54591	0.448	.54599	0.327	.54659	0.132
2452765	.55173	0.142	.55733	0.499	.55698	0.467	.55731	0.343	.55851	0.149
2452766	.56137	0.123	.56430	0.468	.56418	0.440	.56502	0.327	.56445	0.168
2452767	.54455	0.168	.54632	0.518	.54654	0.479	.54529	0.357	.54675	0.159
2452776	.53959	0.280	.54328	0.611	.54325	0.570	.54319	0.439	.54210	0.212
2452778	...	...	...	...	.52319	0.569	...	...	...	...
2452783	.53779	0.388	.53285	0.712	.53142	0.651	.53316	0.507	.52791	0.307
2452784	.53914	0.439	.52331	0.760	.52563	0.689	.52620	0.559	.52332	0.347
2452785	.52699	0.439	.51793	0.768	.51579	0.701	.51617	0.564	.51684	0.368
2452789	.53035	0.589	.52150	0.925	.51801	0.845	.52549	0.720	.52472	0.477
2452790	.53799	0.658	.52399	0.988	.53132	0.922	.53065	0.750	.53227	0.537
2452792	.52509	0.736	.49760	1.053	.50715	0.981	.50787	0.828	.51185	0.582
2452793	.51916	0.763	.51716	1.103	.52349	1.021	.52716	0.867	.52136	0.626
2452794	.48100	0.804	.51445	1.133	.51573	1.054	.49771	0.892	.51477	0.645
2452795	.47197	0.800	.52219	1.108	.46593	1.043	.46248	0.883	.52356	0.630
2452796	...	...	.49899	1.074	.50321	1.014	.51733	0.855	.52067	0.609
2452798	.48089	0.683	.48471	0.990	.48100	0.936	.48271	0.790	.48434	0.546
2452799	.49353	0.637	.49693	0.951	.49907	0.894	.50182	0.749	.50152	0.515
2452800	...	...	.51947	0.892	.52276	0.825	.52514	0.692	.52758	0.456
2452801	...	...	.51660	0.804	.51731	0.755	.51561	0.626	.51059	0.395
2452803	.43021	0.317	.44238	0.637	.44233	0.590	.44656	0.474	.44356	0.277
2452805	...	...	.40439	0.554	.40822	0.520	.40338	0.397	.40517	0.206
2452807	.48001	0.185	.46494	0.514	.46306	0.478	.46424	0.365	.46265	0.170
2452808	.46784	0.169	.46858	0.508	.46863	0.479	.46801	0.361	.46931	0.144
2452815	.51562	0.154	.50313	0.494	.49738	0.455	.50087	0.338	.50353	0.139
2452818	...	...	...	...	.39964	0.471	...	...	...	...
2452820	.45161	0.160	.45133	0.485	.45258	0.456	.44952	0.339	.45251	0.133
2452821	.54204	0.136	.54376	0.493	.54900	0.449	.54549	0.337	.54868	0.134
2452824	...	...	.40417	0.516	.40485	0.459	.40368	0.355	.40434	0.155
2452832	.47416	0.135	.49666	0.506	.47412	0.480	.49257	0.360	.50195	0.166
2452834	.44905	0.118	.45297	0.488	.45749	0.458	.44761	0.336	.45349	0.140
2452836	.54793	0.099	.53299	0.475	.53872	0.443	.53637	0.320	.54058	0.130
2452837	.51369	0.099	.51689	0.457	.51298	0.417	.51053	0.311	.51141	0.122
2452838	...	...	.39151	0.480	.38864	0.448	.38661	0.333	.38459	0.138

*Observers: M. Drahus, M. Kurpińska-Winiarska, A. Majewska, M. Siwak, W. Waniak, M. Winiarski, S. Zoła.

Table B.5. $UBV(RI)_C$ photometry obtained at Kryoneri Observatory* (Greece) during the 2003 eclipse ($E = 9$). The 1.2 m Cassegrain telescope with a CCD camera was used. The differential magnitudes are given with respect to BD +55°2690. Each point is the mean value obtained from several to tens of frames. The columns labelled $JD+$ denote the fraction of the day.

JD	$JD+$	ΔU	$JD+$	ΔB	$JD+$	ΔV	$JD+$	ΔR_C	$JD+$	ΔI_C
2452802	.5545	0.510	.5534	0.680	.5537	0.640	.5552	0.530	.5554	0.340
2452803	.5742	0.325	.5737	0.600	.5739	0.560	.5742	0.465	.5737	0.290
2452804	.5712	0.375	.5715	0.550	.5717	0.505	.5719	0.425	.5721	0.235
2452805	.5726	0.340	.5729	0.520	.5738	0.470	.5726	0.390	.5728	0.200
2452825	.5731	0.120	.5731	0.489	.5731	0.448	.5731	0.331	.5731	0.143
2452826	.5707	0.119	.5707	0.492	.5707	0.456	.5707	0.345	.5707	0.149
2452827	.4723	0.117	.4723	0.472	.4723	0.436	...	...	.4723	0.124

* Observers: I. Bellas-Velidis, A. Dapergolas.

Table B.6. Photometry in standard $UBV(RI)_C$ and narrow (FWHM $\approx 100 \text{ \AA}$) c (continuum at $\bar{\lambda} = 4804 \text{ \AA}$) and $H\beta$ filters obtained at Piwnice Observatory* (Poland) during and near the 2003 eclipse ($E = 9$). A one-channel photometer with a cooled Burle C31034 photomultiplier on the 0.6 m Cassegrain telescope was used. Differential magnitudes are given with respect to BD +55°2690, together with the corresponding standard deviations.

JD	ΔU	ΔB	ΔV	ΔR_C	ΔI_C	Δc^*	$\Delta H\beta^*$	σ_U	σ_B	σ_V	σ_{R_C}	σ_{I_C}	σ_c	$\sigma_{H\beta}$
2452520.4438	0.056	0.479	0.423	0.253	0.098	0.495	0.326	0.013	0.010	0.008	0.009	0.010	0.019	0.031
2452528.4847	0.036	0.449	0.389	0.240	0.090	0.439	0.358	0.012	0.011	0.010	0.009	0.007	0.018	0.026
2452537.3925	0.015	0.455	0.386	0.232	0.072	0.405	0.371	0.014	0.015	0.012	0.008	0.013	0.023	0.033
2452550.4774	0.041	0.477	0.404	0.247	0.073	0.435	0.358	0.011	0.008	0.008	0.006	0.008	0.013	0.024
2452567.4421	0.008	0.431	0.404	0.239	0.085	0.426	0.426	0.013	0.026	0.007	0.008	0.007	0.034	0.027
2452584.5783	0.125	0.501	0.497	0.309	0.131	0.427	0.365	0.043	0.031	0.013	0.012	0.017	0.020	0.024
2452615.4933	-0.007	0.496	0.461	0.252	0.099	0.420	0.355	0.010	0.024	0.018	0.016	0.019	0.005	0.008
2452618.4436	0.049	0.464	0.399	0.257	0.106	0.412	0.433	0.011	0.011	0.008	0.008	0.010	0.009	0.013
2452644.2981	0.043	0.458	0.399	0.233	0.084	0.426	0.346	0.021	0.012	0.013	0.010	0.011	0.008	0.006
2452706.3175	...	...	...	0.227	0.081	0.280	...	...	...	...	0.029	0.024	0.029	...
2452711.6256	0.022	0.458	0.406	0.245	0.086	0.417	0.395	0.014	0.014	0.013	0.011	0.012	0.007	0.015
2452723.5955	0.085	0.476	0.428	0.264	0.103	0.465	0.321	0.012	0.011	0.013	0.010	0.011	0.008	0.016
2452746.5724	0.087	0.494	0.409	0.276	0.107	0.433	0.386	0.011	0.011	0.006	0.007	0.009	0.006	0.020
2452755.4434	0.139	0.509	0.472	0.283	0.140	0.543	0.432	0.029	0.025	0.027	0.032	0.027	0.027	0.020
2452765.5459	0.067	0.461	0.415	0.230	0.111	0.515	0.427	0.026	0.025	0.025	0.020	0.029	0.016	0.009
2452774.5113	0.253	0.615	0.516	0.348	0.192	0.636	0.406	0.010	0.023	0.017	0.023	0.016	0.006	0.010
2452776.4954	0.264	0.623	0.525	0.376	0.214	0.576	0.589	0.013	0.009	0.015	0.005	0.014	0.020	0.003
2452781.5073	0.333	0.765	0.698	0.499	0.255	0.669	0.653	0.009	0.026	0.029	0.029	0.031	0.021	0.040
2452782.4471	0.369	0.701	0.608	0.443	0.253	0.616	0.654	0.016	0.019	0.006	0.018	0.011	0.018	0.058
2452784.4702	0.423	0.804	0.667	0.521	0.352	0.749	0.703	0.014	0.001	0.012	0.012	0.001	0.022	0.014
2452787.4748	0.455	0.800	0.739	0.578	0.389	0.785	0.693	0.002	0.010	0.002	0.009	0.022	0.013	0.010
2452788.4596	0.494	0.870	0.762	0.596	0.425	0.888	0.760	0.004	0.009	0.006	0.018	0.007	0.022	0.006
2452789.4708	0.554	0.952	0.866	0.634	0.510	0.879	0.897	0.017	0.001	0.001	0.019	0.001	0.008	0.023
2452790.4560	0.623	1.020	0.916	0.711	0.508	0.933	0.914	0.028	0.027	0.033	0.038	0.001	0.001	0.018
2452792.4784	0.757	1.102	0.970	0.778	0.564	0.969	1.038	0.003	0.002	0.018	0.011	0.011	0.026	0.053
2452793.4881	0.717	1.071	0.974	0.788	0.531	1.026	0.884	0.006	0.021	0.023	0.019	0.030	0.017	0.040
2452794.4838	0.792	1.140	1.037	0.819	0.604	1.087	0.978	0.016	0.008	0.008	0.001	0.001	0.063	0.001
2452795.4733	0.769	1.116	1.045	0.845	0.589	1.056	1.015	0.004	0.014	0.001	0.015	0.006	0.012	0.014
2452797.5101	0.797	1.092	0.956	0.805	0.602	1.009	1.149	0.034	0.023	0.028	0.017	0.018	0.016	0.025
2452798.4117	0.664	1.018	0.915	0.728	0.520	0.969	0.848	0.015	0.015	0.014	0.010	0.007	0.019	0.048
2452799.5068	0.621	0.999	0.886	0.706	0.497	0.899	0.860	0.014	0.017	0.014	0.008	0.008	0.014	0.020
2452800.4813	0.536	0.898	0.791	0.652	0.454	0.868	0.799	0.002	0.049	0.012	0.017	0.026	0.017	0.048
2452802.4563	0.320	0.736	0.662	0.532	0.332	0.733	0.685	0.026	0.025	0.027	0.003	0.008	0.016	0.004
2452804.4661	0.244	0.615	0.553	0.395	0.226	0.559	0.518	0.001	0.011	0.013	0.008	0.018	0.006	0.018
2452807.4662	0.123	0.538	0.454	0.342	0.167	0.515	0.484	0.024	0.001	0.019	0.011	0.017	0.026	0.022
2452808.4152	0.165	0.514	0.441	0.309	0.119	0.485	0.431	0.013	0.016	0.010	0.012	0.008	0.028	0.013
2452809.5060	0.202	0.532	0.461	0.284	0.107	0.565	0.447	0.030	0.028	0.008	0.010	0.007	0.038	0.044
2452812.4715	0.121	0.520	0.464	0.306	0.117	0.457	0.397	0.008	0.011	0.010	0.005	0.005	0.016	0.029
2452813.4397	0.082	0.509	0.418	0.300	0.112	0.454	0.418	0.020	0.011	0.005	0.007	0.006	0.021	0.032
2452817.4821	0.130	0.512	0.449	0.270	0.115	0.474	0.500	0.026	0.020	0.016	0.016	0.020	0.023	0.019
2452818.4616	0.118	0.529	0.459	0.318	0.116	0.464	0.516	0.010	0.009	0.010	0.007	0.004	0.011	0.032
2452823.5078	0.096	0.489	0.419	0.276	0.099	0.464	0.390	0.013	0.010	0.011	0.013	0.007	0.022	0.030
2452825.4532	0.104	0.487	0.409	0.291	0.101	0.456	0.358	0.010	0.015	0.008	0.012	0.005	0.015	0.040
2452837.4346	0.068	0.489	0.427	0.282	0.101	0.511	0.470	0.008	0.008	0.010	0.008	0.006	0.025	0.042
2452853.5289	0.072	0.482	0.417	0.255	0.107	0.436	0.414	0.010	0.012	0.006	0.006	0.004	0.014	0.030
2452856.5146	0.047	0.457	0.416	0.258	0.081	0.456	0.415	0.010	0.009	0.006	0.007	0.006	0.005	0.007
2452863.4907	0.045	0.489	0.412	0.282	0.126	0.511	0.433	0.016	0.024	0.014	0.023	0.015	0.027	0.031
2452869.4528	0.096	0.486	0.446	0.283	0.108	0.464	0.470	0.005	0.013	0.006	0.006	0.008	0.026	0.028
2452888.5588	0.054	0.482	0.418	0.248	0.120	0.490	0.417	0.007	0.011	0.007	0.009	0.010	0.013	0.028
2452929.4190	0.071	0.468	0.409	0.275	0.074	0.457	0.327	0.015	0.011	0.011	0.017	0.025	0.012	0.021
2452935.5038	0.097	0.520	0.421	0.212	0.068	0.432	0.350	0.040	0.038	0.032	0.023	0.020	0.018	0.001
2452954.4270	-0.060	0.394	0.324	0.240	0.074	0.296	0.268	0.019	0.014	0.012	0.007	0.010	0.023	0.041
2452985.2883	0.050	0.427	0.379	0.263	0.065	...	...	0.010	0.008	0.008	0.007	0.007	...	...
2453008.3696	0.072	0.445	0.413	0.264	0.107	...	...	0.017	0.017	0.009	0.009	0.009	...	...
2453035.2914	0.113	0.468	0.427	0.279	0.111	0.447	0.403	0.014	0.011	0.015	0.010	0.008	0.020	0.022
2453057.2583	0.045	0.461	0.400	0.254	0.088	...	...	0.009	0.010	0.009	0.004	0.006	...	...
2453124.5278	0.114	0.464	0.378	0.243	0.085	...	...	0.012	0.009	0.009	0.006	0.010	...	...
2453150.4178	0.095	0.485	0.415	0.257	0.072	...	...	0.021	0.010	0.014	0.008	0.009	...	...
2453159.4468	0.027	0.460	0.379	0.231	0.047	...	...	0.011	0.008	0.011	0.010	0.006	...	...
2453170.4703	0.055	0.461	0.409	0.219	0.037	...	...	0.013	0.014	0.009	0.008	0.011	...	...
2453202.4900	0.018	0.465	0.390	0.234	0.029	...	...	0.018	0.009	0.008	0.008	0.007	...	...
2453226.4641	0.050	0.482	0.386	0.224	0.040	...	...	0.016	0.009	0.008	0.008	0.007	...	...
2453249.5761	0.025	0.470	0.365	0.213	0.047	...	...	0.010	0.011	0.013	0.009	0.008	...	...
2453291.4884	0.008	0.422	0.379	0.224	0.059	...	...	0.018	0.009	0.010	0.008	0.013	...	...

* Observers: C. Gałań, A. Majcher, M. Mikołajewski.

Table B.7. $UBV(RI)_C$ photometry obtained at Rozhen Observatory* (Bulgaria) during the 2003 eclipse ($E = 9$). The 2 m Ritchey-Chrétien telescope with a CCD camera was used. The differential magnitudes are given with respect to BD +55°2690. The columns labelled $JD+$ denote the fraction of the day.

JD	$JD+$	ΔU	$JD+$	ΔB	$JD+$	ΔV	$JD+$	ΔR_C	$JD+$	ΔI_C
2452754	...	...	...	...	.5367	0.399	.5364	0.343	.5368	0.100
2452759	...	...	...	...	...	...	.5023	0.338	...	...
2452760	...	...	...	...	.5024	0.376	.5023	0.298	...	...
2452791	.5259	0.751	.5222	1.089	.5231	0.892	.5276	0.840	.5298	0.682
2452792	.5465	0.680	.5529	0.959	.5410	0.797	.5392	0.534	.5356	0.451

* Observers: M. Gromadzki, D. Kolev.

Table B.8. Photometry in the V filter obtained at Rozhen Observatory* (Bulgaria) during the 2003 eclipse ($E = 9$). The 0.5/0.7 m Schmidt telescope with a CCD camera was used. The differential magnitudes are given with respect to the BD +55°2690 comparison star.

JD	ΔV
2452756.4912	0.427
2452758.5752	0.381
2452759.5894	0.369

* Observers: G. Apostolovska, B. Bilkina, M. Gromadzki, D. Kolev.

Table B.9. UBV photometry obtained at Rozhen Observatory* (Bulgaria) during the 2003 eclipse ($E = 9$). The 0.6 m Cassegrain telescope with a one-channel photomultiplier was used. The differential magnitudes are given with respect to BD +55°2690.

JD	ΔU	ΔB	ΔV
2452760.575	0.021	0.404	0.412
2452761.571	0.079	0.463	0.437
2452799.505	0.497	0.845	0.802
2452801.516	0.402	0.749	0.731
2452811.510	0.089	0.469	0.438
2452821.503	0.070	0.450	0.439

* Observer: D. Dimitrov.

Table B.10. $UBV(RI)_C$ photometry obtained at Skinakas Observatory* (Crete, Greece) during the 2003 eclipse ($E = 9$). The 1.3 m Ritchey-Chrétien telescope with a CCD camera was used. The differential magnitudes are given with respect to BD +55°2690.

JD	ΔU	ΔB	ΔV	ΔR_C	ΔI_C
2452798.578	...	0.98	0.91	0.77	0.55
2452799.585	0.67	0.94	0.87	0.74	0.52
2452801.577	0.52	0.79	0.73	0.61	0.40
2452802.579	0.43	0.70	0.64	0.53	0.34
2452803.599	0.36	0.63	0.58	0.48	0.29
2452804.587	0.29	0.63	0.53	0.42	0.23
2452805.587	0.26	0.54	0.49	0.39	0.205
2452806.579	0.24	0.525	0.48	0.38	0.19
2452807.579	0.22	0.515	0.46	0.36	0.175

* Observer: E. Semkov.

Table B.11. $BV(RI)_C$ photometry obtained at Piskésető Observatory* (Hungary) during the 2003 eclipse ($E = 9$). The 0.6/0.9 m Schmidt telescope with an AT200 CCD camera was used. The differential magnitudes are given with respect to BD +55°2690.

HJD	ΔB	ΔV	ΔR_C	ΔI_C
2452776.563	0.592	0.516	0.393	0.215
2452778.565	0.620	0.545	0.430	0.245
2452779.568	0.660	0.590	0.460	0.270

* Observers: B. Csák, B. Gere, P. Németh.

Table B.12. $BV(RI)_C$ photometric data obtained at Altan Observatory* (Czech Republic) during the 2008/9 eclipse ($E = 10$). The 0.2 meter RL Vixen VMC200L telescope with a G2-0402 CCD camera was used. Differential magnitudes are given with respect to BD +55°2690 together, with the corresponding standard deviations.

HJD	$HJD+$	ΔB	σ_B	$HJD+$	ΔV	σ_V	$HJD+$	ΔR	σ_{R_C}	$HJD+$	ΔI	σ_{I_C}
2454810	.1966	0.476	0.029	.1989	0.422	0.004	.1966	0.298	0.010	.1895	0.161	0.013
2454824	.3541	0.536	0.012	.3596	0.477	0.006	.3533	0.352	0.005	.3533	0.183	0.005
2454828	.3614	0.569	0.014	.3529	0.490	0.013	.3595	0.393	0.006	.3485	0.215	0.009
2454829	.1900	0.591	0.014	.1927	0.551	0.002	.1917	0.424	0.002	.1896	0.245	0.004
2454830	.1965	0.693	0.008	.1975	0.602	0.003	.1952	0.461	0.004	.1945	0.281	0.002
2454831	.1936	0.730	0.011	.1926	0.640	0.005	.1917	0.503	0.005	.1946	0.317	0.004
2454832	.2061	0.738	0.005	.2070	0.627	0.005	.2061	0.490	0.005	.2045	0.310	0.004
2454835	.1856	0.711	0.068	.1792	0.667	0.009	.1879	0.569	0.049	.1820	0.299	0.012
2454840	.3251	0.937	0.014	.3222	0.836	0.008	.3212	0.699	0.013	.3203	0.524	0.022
2454843	.2002	0.961	0.009	.1967	0.842	0.007	.1958	0.686	0.009	.1986	0.484	0.007
2454844	.2440	0.915	0.010	.2431	0.842	0.005	.2441	0.702	0.007	.2450	0.490	0.003
2454845	.2532	0.891	0.021	.2541	0.779	0.004	.2532	0.645	0.005	.2542	0.467	0.015
2454854	.2473	0.597	0.002	.2483	0.525	0.004	.2474	0.389	0.004	.2464	0.208	0.004
2454857	.2190	0.565	0.013	.2161	0.474	0.011	.2152	0.365	0.005	.2032	0.188	0.003
2454860	.2400	0.530	0.012	.2390	0.459	0.007	.2381	0.319	0.004	.2371	0.170	0.002

* Observer: L. Brát.

Table B.13. $BV(RI)_C$ photometric data obtained at Białków Observatory* (Poland) during the 2008/9 eclipse ($E = 10$). The 0.6 m Cassegrain telescope with a CCD camera was used. Differential magnitudes are given with respect to BD +55°2690. The columns labelled $HJD+$ denote the fraction of the day.

HJD	$HJD+$	ΔB	$HJD+$	ΔV	$HJD+$	ΔR_C	$HJD+$	ΔI_C
2454814	.30228	0.521	.31205	0.459	.31825	0.348	.29353	0.176
2454815	.17723	0.518	.18402	0.460	.18773	0.346	.17027	0.179
2454816	.21367	0.505	.20595	0.444	...	...	.19731	0.170
2454831	.16875	0.701	.17475	0.617	.17954	0.494	.18382	0.318
2454834	.22008	0.689	.22197	0.607	.22323	0.485	.22447	0.315
2454837	.20076	0.733	.20672	0.660	.21128	0.541	.21535	0.368
2454838	.18539	0.779	.19092	0.708	.19458	0.587	.19824	0.410
2454840	.29154	0.903	.29343	0.823	.29468	0.689	.29593	0.501
2454843	.18047	0.924	.18543	0.841	.18913	0.708	.19283	0.517
2454844	.17864	0.883	.18479	0.812	.18909	0.684	.19280	0.494
2454845	.18903	0.834	.19402	0.765	.19771	0.641	.20141	0.463

* Observers: G. Kopacki, A. Majewska, A. Narwid, E. Niemczura, A. Pigulski, M. Stęśliński

Table B.14. $BV(RI)_C$ photometric data obtained at Green Island Observatory* (North Cyprus) during the 2008/9 eclipse ($E = 10$). The 0.35 m telescope (Meade 14" LX200R) with a Meade DSI II Pro CCD camera was used. Differential magnitudes are given with respect to BD +55°2690 together with the corresponding standard deviations. The columns labelled $JD+$ denote the fraction of the day.

JD	$JD+$	ΔB	σ_B	$JD+$	ΔV	σ_V	$JD+$	ΔR	σ_{R_C}	$JD+$	ΔI	σ_{I_C}
2454810	.20398	0.500	0.005	.19671	0.443	0.009	.20988	0.325	0.012	.21571	0.178	0.007
2454820	.23238	0.488	0.005	.23920	0.447	0.010	.24587	0.326	0.006	.25252	0.195	0.003
2454849	.17309	0.702	0.015	.18015	0.657	0.012	.18716	0.526	0.008	.19584	0.346	0.023
2454852	.18026	0.599	0.004	.18916	0.543	0.016	.19609	0.428	0.006	.20456	0.268	0.019
2454854	.21422	0.561	0.005	.22135	0.502	0.020	.22853	0.369	0.003	.23729	0.244	0.015
2454858	.18768	0.509	0.010	.19550	0.459	0.019	.20248	0.343	0.008	.21265	0.188	0.019
2454860	.19138	0.503	0.001	.18434	0.440	0.009	.19978	0.323	0.008	.17670	0.172	0.016
2454865	.17912	0.496	0.005	.18599	0.438	0.003	.19291	0.316	0.005	.20348	0.183	0.004
2454878	...	...	...	.18347	0.455	0.009	.18899	0.325	0.010	.19432	0.169	0.009

* Observer: Y. Ögmen.

Table B.15. $BV(RI)_C$ photometric data obtained at Furzehill House Observatory* (Ilston, Swansea, United Kingdom) during the 2008/9 eclipse ($E = 10$). The 0.35 m Schmidt-Cassegrain telescope with an SXVF-H16 CCD camera was used. Differential magnitudes are given with respect to BD +55°2690, together with the corresponding standard deviations. The columns labelled $HJD+$ denote the fraction of the day.

HJD	$HJD+$	ΔB	σ_B	$HJD+$	ΔV	σ_V	$HJD+$	ΔR	σ_{R_C}	$HJD+$	ΔI	σ_{I_C}
2454815	.39684	0.496	0.005	.39406	0.472	0.004	...	...	...	...	...	...
2454816	.36785	0.478	0.009	.35943	0.439	0.006	...	...	...	...	...	...
2454827	.26603	0.539	0.004	.26977	0.512	0.003	.27370	0.392	0.003	.27740	0.221	0.009
2454828	.26105	0.551	0.004	.26495	0.506	0.003	.26900	0.410	0.003	.27280	0.236	0.007
2454829	.27405	0.595	0.003	.27958	0.532	0.003	.28370	0.426	0.003	.28984	0.256	0.005
2454831	.25665	0.673	0.003	.26239	0.622	0.004	.26650	0.506	0.004	.27228	0.333	0.006
2454834	.28341	0.679	0.003	.30354	0.604	0.003	.29910	0.500	0.003	.29261	0.329	0.005
2454835	.25826	0.657	0.003	.27667	0.614	0.003	.27270	0.492	0.003	.26649	0.331	0.005
2454837	.25763	0.725	0.003	.27688	0.678	0.003	.27270	0.549	0.003	.26606	0.383	0.005
2454838	.26906	0.780	0.003	.29043	0.754	0.004	.28560	0.596	0.004	.27763	0.439	0.005
2454839	.33017	0.845	0.003	.35110	0.773	0.004	.34680	0.659	0.004	.34021	0.481	0.005
2454852	.32291	0.602	0.003	.34376	0.555	0.004	.33940	0.453	0.004	.33353	0.277	0.006
2454855	.30354	0.534	0.003	.33404	0.515	0.006	.32830	0.389	0.004	.31159	0.222	0.005
2454858	.30088	0.502	0.003	.33170	0.459	0.004	.32312	0.370	0.005	.31639	0.202	0.006
2454866	.29978	0.487	0.003	.31625	0.455	0.004	.31257	0.333	0.004	.30715	0.182	0.005
2454869	.30427	0.489	0.003	.33609	0.437	0.004	.32837	0.332	0.004	.32114	0.157	0.006
2454871	.32916	0.474	0.006	.30698	0.466	0.005	.30204	0.342	0.005	.29362	0.168	0.005
2454878	.29032	0.503	0.004	.30275	0.461	0.006	.29972	0.352	0.006	.29484	0.197	0.008

* Observer: I. Miller.

Table B.16. Photometry in the V filter obtained at Observatorio Astronómico "Las Pegueras"* (Navas de Oro, Segovia, Spain) during the 2008/9 eclipse ($E = 10$). The 0.35 m Reflector with a CCD camera was used. Differential magnitudes are given with respect to BD +55°2690.

JD	ΔV
2454815.2834	-0.43
2454817.2900	-0.39
2454820.2953	-0.42
2454823.2650	-0.40
2454824.2668	-0.39
2454825.2556	-0.37
2454826.2524	-0.35
2454836.3460	-0.21
2454839.2727	-0.07
2454842.2511	0.01
2454843.2532	0.00
2454846.2701	-0.15
2454848.3420	-0.20
2454849.2724	-0.22
2454856.3162	-0.37
2454863.3053	-0.43

* Observer: T. A. Heras.

Table B.17. Photometry obtained at Ostrava Observatory* (Czech Republic) with standard $BV(RI)_C$ filters during the 2008/9 eclipse ($E = 10$). The 0.3 m Schmidt-Cassegrain telescope with a CCD camera has been used. Differential magnitudes are given with respect to BD +55°2690. The columns labelled $JD+$ denote the fraction of the day.

JD	$JD+$	ΔB	$JD+$	ΔV	$JD+$	ΔR_C	$JD+$	ΔI_C
2454830	.3938	0.652	.3913	0.581	.3912	0.440	.3928	0.248

* Observer: R. Kocián.

Table B.18. $BV(RI)_C$ photometry obtained at Rozhen Observatory* (Bulgaria) during the 2008/9 eclipse ($E = 10$). The 2 m Ritchey-Chrétien telescope with a CCD camera was used. Differential magnitudes are given with respect to BD +55°2690. The columns labelled $JD+$ denote the fraction of the day.

JD	$JD+$	ΔB	$JD+$	ΔV	$JD+$	ΔR_C	$JD+$	ΔI_C
2454827	.370	0.52	.365	0.47	.363	0.36	.361	0.21

* Observers: S. Peneva, E. Semkov.

Table B.19. $UBV(RI)_C$ photometry obtained at Rozhen Observatory* (Bulgaria) during and near the 2008/9 eclipse ($E = 10$). The 0.5/0.7 m Schmidt telescope with a CCD camera was used. The differential magnitudes are given with respect to BD +55°2690. The columns labelled $JD+$ denote the fraction of the day.

JD	$JD+$	ΔU	$JD+$	ΔB	$JD+$	ΔV	$JD+$	ΔR_C	$JD+$	ΔI_C
2454762	...	0.12	...	0.46	...	0.42	...	0.32	...	0.16
2454764	...	0.12	...	0.46	...	0.41	...	0.31	...	0.15
2454830	...	...	...	...	...	...	.275	0.48	.270	0.29
2454842	...	...	.191	0.95	.186	0.86	.182	0.73	.176	0.52
2454843	.191	0.62	.186	0.94	.183	0.85	.180	0.73	.175	0.54
2454844	.190	0.57	.186	0.90	.183	0.82	.180	0.69	.176	0.49
2454845	...	...	.294	0.81	.269	0.75	.265	0.64	.250	0.45

* Observers: S. Peneva, E. Semkov.

Table B.20. Photometry obtained at Rozhen Observatory* (Bulgaria) during the 2008/9 eclipse ($E = 10$) with standard $UBV(RI)_C$ (Bessell) filters. The 0.6 m Cassegrain telescope with a FLI PL09000 CCD camera was used. Differential magnitudes are given with respect to BD +55°2690. Each point is the mean value obtained from several frames. The columns labelled $HJD+$ denote the fraction of the day.

HJD	$HJD+$	ΔU	$HJD+$	ΔB	$HJD+$	ΔV	$HJD+$	ΔR_C	$HJD+$	ΔI_C
2454808	.34867	0.190	.35088	0.502	.35202	0.451	.35264	0.348	.35308	0.146
2454808	.41329	0.178	.41551	0.494	.41054	0.424	.41115	0.332	.41159	0.133
2454810	.24350	0.197	.24571	0.511	.24685	0.454	.24746	0.355	.24791	0.159
2454832	.17438	0.420	.17467	0.698	.17611	0.615	.17721	0.501	.17795	0.296
2454858	...	...	.23000	0.533	.23000	0.453	.23000	0.362	.23000	0.163
2454869	.21210	0.185	.21241	0.497	.21034	0.445	.21155	0.341	.21494	0.155
2454886	.21908	0.178	.22383	0.483	.22219	0.440	.22340	0.326	.22425	0.136

* Observers: D. Dimitrov, V. Popov.

Table B.21. $BV(RI)_C$ photometry obtained at Kryoneri Observatory* (Greece) at the beginning of the 2008/9 eclipse ($E = 10$). The 1.2 m Cassegrain telescope with a CCD camera was used. Differential magnitudes are given with respect to BD +55°2691. The columns labelled $HJD+$ denote the fraction of the day.

HJD	$HJD+$	ΔB	$HJD+$	ΔV	$HJD+$	ΔR_C	$HJD+$	ΔI_C
2454774	.2517	-0.413	.2792	-0.458	.2863	-0.576	.2911	-0.761
2454775	.3071	-0.372	.3043	-0.456	.2932	-0.560	.3011	-0.748

* Observers: I. Bellas-Velidis, A. Dapergolas.

Table B.22. $BV(RI)_C$ photometry obtained at Sonoita Research Observatory* (Arizona, USA) during and near the 2008/9 eclipse ($E = 10$). The 0.5 m Cassegrain telescope with an SBIG STL 6303 CCD camera was used. Comparisons were made against two stars designated with the AAVSO Unique Identifiers as: 000-BCQ-040, 000-BJJ-300. The former is a d object from Meinunger's comparison star sequence (Meinunger 1975). The apparent magnitudes are also given with respect to BD +55°2690 (calculated with the adoption of $BV(RI)_C$ magnitudes of BD +55°2690 given in Mikořajewski et al. (2003)). The columns labelled $HJD+$ denote the fraction of the day.

HJD	$HJD+$	B	ΔB	$HJD+$	V	ΔV	$HJD+$	R_C	ΔR_C	$HJD+$	I_C	ΔI_C
2454790	.6019	11.140	0.460	.6022	10.800	0.420	.6003	10.510	0.420	.6020	10.155	0.285
2454791	.7615	11.155	0.475	.7618	10.805	0.425	.7618	10.515	0.425	.7618	10.165	0.295
2454792	.7133	11.170	0.490	.7135	10.810	0.430	.7136	10.525	0.435	.7134	10.165	0.295
2454801	.5847	11.155	0.475	.5850	10.815	0.435	.5851	10.525	0.435	.5850	10.180	0.310
2454804	.7281	11.160	0.480	.7282	10.825	0.445	.7282	10.585	0.445	.7282	10.200	0.330
2454806	.6826	11.170	0.490	.6827	10.815	0.435	.6828	10.560	0.435	.6827	10.195	0.325
2454807	.7415	11.170	0.490	.7417	10.820	0.440	.7417	10.610	0.440	.7416	10.195	0.325
2454809	.7298	11.175	0.495	.7300	10.830	0.450	.7301	10.545	0.455	.7300	10.190	0.320
2454810	.6454	11.185	0.505	.6457	10.825	0.445	.6458	10.555	0.465	.6456	10.215	0.345
2454811	.6918	11.180	0.500	.6920	10.830	0.450	.6920	10.545	0.455	.6919	10.200	0.330
2454812	.6638	11.175	0.495	.6640	10.830	0.450	.6640	10.545	0.455	.6639	10.205	0.335
2454816	.7199	11.195	0.515	.7201	10.835	0.455	.7202	10.550	0.460	.7201	10.210	0.340
2454821	.6856	11.190	0.510	.6859	10.835	0.455	.6859	10.540	0.450	.6859	10.215	0.345
2454829	.5868	11.290	0.610	.6801	10.895	0.515	.6802	10.610	0.520	.6801	10.270	0.400
2454828	.6799	11.260	0.580	.5875	10.930	0.550	.5876	10.640	0.550	.5875	10.285	0.415
2454830	.5858	11.325	0.645	.5861	10.950	0.570	.5861	10.660	0.570	.5860	10.290	0.420
2454837	.57280	11.440	0.760	.57295	11.060	0.680	.57310	10.765	0.675	.57280	10.415	0.545
2454838	.57290	11.480	0.800	.57310	11.115	0.735	.57320	10.810	0.720	.57310	10.460	0.590
2454839	.57145	11.560	0.880	.57170	11.180	0.800	.57175	10.870	0.780	.57165	10.515	0.645
2454840	.58085	11.605	0.925	.58115	11.230	0.850	.58120	10.920	0.830	.58105	10.550	0.680
2454841	.59040	11.625	0.945	.59065	11.230	0.850	.59065	10.930	0.840	.59050	10.560	0.690
2454842	.61965	11.625	0.945	.61995	11.240	0.860	.61995	10.925	0.835	.61980	10.545	0.675
2454843	.57510	11.600	0.920	.57540	11.215	0.835	.57540	10.910	0.820	.57530	10.555	0.685
2454844	.61630	11.565	0.885	.61655	11.175	0.795	.61660	10.885	0.795	.61645	10.530	0.660
2454846	.61500	11.485	0.805	.61530	11.110	0.730	.61530	10.825	0.735	.61515	10.470	0.600
2454847	.61645	11.440	0.760	.61665	11.080	0.700	.61670	10.785	0.695	.61655	10.435	0.565
2454848	.57710	11.410	0.730	.57735	11.055	0.675	.57740	10.760	0.670	.57725	10.410	0.540
2454849	.60140	11.380	0.700	.60165	11.010	0.630	.60170	10.725	0.635	.60155	10.370	0.500
2454850	.60925	11.340	0.660	.60955	10.985	0.605	.60955	10.690	0.600	.60940	10.345	0.475
2454857	.58720	11.200	0.520	.58745	10.850	0.470	.58750	10.575	0.485	.58740	10.215	0.345
2454858	.59370	11.195	0.515	.59395	10.830	0.450	.59400	10.555	0.465	.59380	10.210	0.340
2454860	.58890	11.180	0.500	.58915	10.820	0.440	.58920	10.550	0.460	.58905	10.205	0.335
2454861	.58450	11.160	0.480	.58470	10.815	0.435	.58475	10.530	0.440	.58460	10.200	0.330
2454862	.58525	11.175	0.495	.58550	10.825	0.445	.58550	10.535	0.445	.58545	10.200	0.330
2454863	.58500	11.180	0.500	.58525	10.845	0.465	.58530	10.535	0.445	.58515	10.190	0.320
2454864	.58570	11.180	0.500	.58595	10.830	0.450	.58600	10.550	0.460	.58585	10.200	0.330
2454865	.58600	11.180	0.500	.58625	10.820	0.440	.58630	10.545	0.455	.58615	10.205	0.335
2454867	.58970	11.170	0.490	.58990	10.815	0.435	.58995	10.530	0.440	.58980	10.190	0.320
2454869	.58750	11.150	0.470	.58825	10.795	0.415	.58830	10.495	0.405	.58815	10.165	0.295
2454870	.58935	11.160	0.480	.58960	10.815	0.435	.58965	10.540	0.450	.58950	10.195	0.325
2454879	.59660	11.195	0.515	.59685	10.820	0.440	.59690	10.515	0.425	.59675	10.205	0.335
2454881	.59585	11.200	0.520	.59615	10.830	0.450	.59615	10.545	0.455	.59590	10.210	0.340
2454882	.59465	11.190	0.510	.59490	10.830	0.450	.59495	10.525	0.435	.59485	10.205	0.335
2454885	.02960	11.175	0.495	.02985	10.825	0.445	.02990	10.540	0.450	.02975	10.180	0.310
2454890	.02490	11.165	0.485	.02520	10.815	0.435	.02525	10.525	0.435	.02510	10.185	0.315
2454891	.01930	11.165	0.485	.01955	10.815	0.435	.01960	10.525	0.435	.01945	10.185	0.315
2454893	.01010	11.145	0.465	.01040	10.810	0.430	.01045	10.525	0.435	.01030	10.180	0.310
2454894	.01105	11.175	0.495	.01125	10.815	0.435	.01135	10.525	0.435	.01105	10.200	0.330
2454895	.01540	11.125	0.445	.01570	10.770	0.390	.01575	10.485	0.395	.01560	10.160	0.290

* Observer: B. Staels.

Table B.23. $BV(RI)_C$ photometry obtained at Sonoita Research Observatory* (Arizona, USA) during and near the 2008/9 eclipse ($E = 10$). The 0.5 m Cassegrain telescope with an SBIG STL 6303 CCD camera was used. The apparent magnitudes are also given with respect to BD +55°2690 (calculated by adopting $BV(RI)_C$ magnitudes of BD +55°2690 from Mikołajewski et al. (2003)).

JD	B	ΔB	σ_B	V	ΔV	σ_V	R_C	ΔR_C	σ_{R_C}	I_C	ΔI_C	σ_{I_C}
2454790.60	11.14	0.46	0.02	10.79	0.41	0.01	10.38	0.29	...	10	0.13	0.02
2454791.76	11.15	0.47	0.03	10.79	0.41	0.01	10.38	0.29	0.02	10.01	0.14	0.02
2454801.58	11.16	0.48	0.03	10.79	0.41	0.01	10.39	0.30	...	10.01	0.14	0.02
2454804.72	11.17	0.49	0.03	10.78	0.40	0.04	10.4	0.31	0.07	10.02	0.15	0.01
2454806.68	11.17	0.49	0.03	10.8	0.42	0.01	10.4	0.31	0.04	10.02	0.15	0.02
2454807.74	11.18	0.50	0.03	10.79	0.41	0.03	10.42	0.33	0.09	10.03	0.16	0.01
2454809.73	11.18	0.50	0.02	10.81	0.43	0.01	10.41	0.32	0.01	10.05	0.18	0.06
2454810.64	11.19	0.51	0.02	10.82	0.44	0.01	10.42	0.33	0.02	10.04	0.17	0.01
2454811.69	11.19	0.51	0.03	10.81	0.43	0.01	10.4	0.31	0.01	10.03	0.16	0.01
2454812.66	11.19	0.51	0.03	10.81	0.43	0.01	10.41	0.32	0.01	10.03	0.16	0.01
2454816.72	11.19	0.51	0.03	10.82	0.44	0.01	10.4	0.31	0.01	10.04	0.17	0.01
2454821.68	11.19	0.51	0.02	10.81	0.43	0.01	10.4	0.31	0.01	10.04	0.17	0.02
2454828.68	11.26	0.58	0.02	10.87	0.49	0.01	10.46	0.37	0.02	10.09	0.22	0.01
2454829.58	11.18	0.50	...	10.94	0.56	0.07	10.49	0.40	0.01	10.11	0.24	0.02
2454830.58	11.36	0.68	0.02	10.96	0.58	0.01	10.54	0.45	0.01	10.14	0.27	0.02
2454838.57	11.49	0.81	0.02	11.09	0.71	0.01	10.67	0.58	0.01	10.29	0.42	0.02
2454839.57	11.56	0.88	0.03	11.15	0.77	0.01	10.73	0.64	0.01	10.34	0.47	0.02
2454840.58	11.61	0.93	0.02	11.21	0.83	0.01	10.78	0.69	0.01	10.37	0.50	0.01
2454841.59	11.63	0.95	0.02	11.21	0.83	0.02	10.78	0.69	0.01	10.38	0.51	0.02
2454842.62	11.62	0.94	0.03	11.21	0.83	0.01	10.78	0.69	0.01	10.37	0.50	0.02
2454843.57	11.6	0.92	0.02	11.2	0.82	0.01	10.77	0.68	0.01	10.37	0.50	0.02
2454844.61	11.56	0.88	0.03	11.16	0.78	0.01	10.74	0.65	0.01	10.35	0.48	0.01
2454846.61	11.49	0.81	0.02	11.1	0.72	0.02	10.69	0.60	0.01	10.29	0.42	0.02
2454847.61	11.44	0.76	0.03	11.07	0.69	0.01	10.65	0.56	0.01	10.27	0.40	0.02
2454848.57	11.41	0.73	0.03	11.04	0.66	0.01	10.62	0.53	0.01	10.23	0.36	0.02
2454849.60	11.38	0.70	0.03	11	0.62	0.01	10.58	0.49	0.01	10.19	0.32	0.01
2454850.61	11.34	0.66	0.03	10.97	0.59	0.02	10.54	0.45	0.01	10.17	0.30	0.02
2454857.58	11.2	0.52	0.03	10.83	0.45	0.01	10.43	0.34	0.01	10.04	0.17	0.02
2454858.60	11.2	0.52	0.03	10.82	0.44	0.02	10.42	0.33	0.01	10.04	0.17	0.02
2454860.59	11.18	0.50	0.03	10.81	0.43	0.01	10.4	0.31	0.01	10.03	0.16	0.01
2454861.58	11.18	0.50	0.03	10.8	0.42	0.01	10.39	0.30	0.01	10.02	0.15	0.02
2454861.58	11.18	0.50	0.03	10.8	0.42	0.01	10.39	0.30	0.01	10.02	0.15	0.02
2454862.58	11.18	0.50	0.02	10.81	0.43	0.01	10.39	0.30	0.01	10.02	0.15	0.02
2454863.58	11.17	0.49	0.03	10.8	0.42	0.01	10.39	0.30	0.01	10.02	0.15	0.02
2454865.59	11.18	0.50	0.03	10.8	0.42	0.01	10.4	0.31	0.01	10.02	0.15	0.02
2454867.59	11.18	0.50	...	10.8	0.42	...	10.41	0.32	...	10.02	0.15	...
2454869.58	11.17	0.49	0.03	10.8	0.42	0.01	10.38	0.29	0.01	10.02	0.15	0.01
2454870.59	11.18	0.50	0.03	10.81	0.43	0.01	10.39	0.30	0.02	10.01	0.14	0.02
2454879.59	11.19	0.51	0.02	10.81	0.43	0.02	10.37	0.28	0.02	10.03	0.16	0.02

* Observers: L. Elder, J. Hopkins, J. Pye.

Table B.24. Photometry obtained at Athens Observatory* (Greece) with standard $BV(RI)_C$ (Bessell) filters during and near the 2008/9 eclipse ($E = 10$). The 0.4 m Cassegrain telescope with an SBIG ST-8XMEI CCD camera was used. Differential magnitudes are given with respect to three comparison stars: $a = \text{BD } +55^\circ 2690$, $b = \text{GSC-3973:2150}$, and $c = \text{BD } +55^\circ 2691$. Each point is the mean value obtained from several frames. The columns labelled $HJD+$ denote the fraction of the day.

	ΔB				ΔV				ΔR_C				ΔI_C			
HJD	$HJD+$	$v-a$	$v-b$	$v-c$	$HJD+$	$v-a$	$v-b$	$v-c$	$HJD+$	$v-a$	$v-b$	$v-c$	$HJD+$	$v-a$	$v-b$	$v-c$
2454791	.3793	0.470	-0.293	-0.343	.3805	0.428	-0.419	-0.431	.3812	0.305	-0.602	-0.564	.3818	0.152	-0.799	-0.721
2454792	.4465	0.465	-0.317	-0.348	.4477	0.423	-0.444	-0.440	.4484	0.305	-0.603	-0.569	.4490	0.153	-0.814	-0.723
2454796	.1741	0.461	-0.295	-0.350	.1753	0.421	-0.426	-0.435	.1759	0.302	-0.599	-0.573	.1766	0.138	-0.825	-0.736
2454798	.1742	0.462	-0.300	-0.348	.1754	0.425	-0.424	-0.436	.1761	0.314	-0.596	-0.564	.1767	0.145	-0.813	-0.728
2454804	.1734	0.475	-0.292	-0.345	.1746	0.432	-0.427	-0.433	.1752	0.320	-0.596	-0.565	.1758	0.148	-0.813	-0.712
2454809	.1717	0.495	-0.268	-0.319	.1729	0.455	-0.396	-0.408	.1736	0.336	-0.577	-0.538	.1742	0.166	-0.796	-0.708
2454824	.3406	0.525	-0.239	-0.301	.3417	0.479	-0.366	-0.389	.3424	0.354	-0.546	-0.519	.3431	0.184	-0.771	-0.688
2454825	.1721	0.530	-0.234	-0.284	.1733	0.488	-0.356	-0.378	.1740	0.374	-0.525	-0.503	.1746	0.194	-0.753	-0.676
2454851	.1886	0.630	-0.137	-0.189	.1895	0.583	-0.272	-0.289	.1901	0.465	-0.442	-0.411	.1906	0.286	-0.667	-0.589
2454882	.1990	0.521	-0.255	-0.305	.2000	0.457	-0.375	-0.388	.2005	0.340	-0.559	-0.537	.2011	0.168	-0.761	-0.670
2454883	.2032	0.506	-0.258	-0.310	.2042	0.437	-0.408	-0.420	.2047	0.320	-0.586	-0.541	.2053	0.142	-0.814	-0.739

* Observers: K. Gazeas, A. Liakos, P. Niarchos.

Table B.25. Photometry obtained at Hankasalmi Observatory* (Finland) with standard $BV(RI)_C$ (Bessell) filters during the 2008/9 eclipse ($E = 10$). The 0.4 m RCOS telescope with an SBIG STL-1001 CCD camera was used. Differential magnitudes are given with respect to three comparison stars: $a = \text{BD } +55^\circ 2690$, $b = \text{GSC-3973:2150}$, and $c = \text{BD } +55^\circ 2691$. Each point is the mean value obtained from several frames. The columns labelled $HJD+$ denote the fraction of the day.

	ΔB				ΔV			ΔR_C			ΔI_C			
HJD	$HJD+$	$v-a$	$v-b$	$v-c$	$HJD+$	$v-b$	$v-c$	$HJD+$	$v-b$	$v-c$	$HJD+$	$v-a$	$v-b$	$v-c$
2454828	.3851	0.579	-0.195	-0.245	.3822	-0.340	-0.351	.3872	-0.506	-0.470	.3862	0.195	-0.755	-0.662
2454833	.1808	0.705	-0.057	-0.112	.1779	-0.228	-0.242	.1827	-0.400	-0.370	.1848	0.292	-0.668	-0.574
2454836	.1388	0.693	-0.061	-0.118	.1358	-0.217	-0.235	.1406	-0.381	-0.359	.1430	0.315	-0.640	-0.547
2454839	.2096	0.854	0.093	0.034	.2070	-0.068	-0.086	.2116	-0.250	-0.221	.2135	0.430	-0.522	-0.431
2454848	.3753	0.768	-0.020	-0.080	.3722	-0.171	-0.192	.3772	-0.351	-0.316	.3790	0.370	-0.595	-0.512
2454862	.3108	0.502	-0.265	-0.313	.3082	-0.403	-0.419	.3129	-0.569	-0.542	.3147	0.140	-0.812	-0.723
2454865	.1540	0.496	-0.262	-0.317	.1511	-0.409	-0.422	.1559	-0.567	-0.539	.1579	0.131	-0.819	-0.731

* Observer: A. Oksanen.

Table B.26. Photometry obtained at Ostrava Observatory* (Czech Republic) with standard $BV(RI)_C$ filters during the 2008/9 eclipse ($E = 10$). The 0.2 m Newton telescope with an SBIG ST8-XME CCD camera has been used. Differential magnitudes are given with respect to three comparison stars: $a = \text{BD } +55^\circ 2690$, $b = \text{GSC-3973:2150}$, and $c = \text{BD } +55^\circ 2691$. Each point is the mean value obtained from several frames. The columns labelled $HJD+$ denote the fraction of the day.

	ΔB				ΔV				ΔR_C				ΔI_C			
HJD	$HJD+$	$v-a$	$v-b$	$v-c$	$HJD+$	$v-a$	$v-b$	$v-c$	$HJD+$	$v-a$	$v-b$	$v-c$	$HJD+$	$v-a$	$v-b$	$v-c$
2454810	.3006	0.475	-0.245	-0.317	.2972	0.438	-0.412	-0.421	.2983	0.327	-0.564	-0.540	.3017	0.152	-0.784	-0.700
2454815	.3856	0.504	-0.223	-0.295	.3822	0.447	-0.398	-0.406	.3833	0.346	-0.548	-0.520	.3844	0.162	-0.781	-0.701
2454841	.3133	0.929	0.209	0.139	.3099	0.848	-0.009	-0.009	.3087	0.709	-0.184	-0.153	.3121	0.493	-0.454	-0.358
2454843	.2011	0.925	0.200	0.137	.1970	0.846	0.003	-0.016	.1982	0.724	-0.167	-0.152	.1993	0.510	-0.431	-0.359
2454850	.2206	0.662	-0.070	-0.125	.2194	0.611	-0.248	-0.249	.2206	0.494	-0.404	-0.379	.2217	0.303	-0.647	-0.559
2454857	.2009	0.504	-0.221	-0.282	.1975	0.461	-0.391	-0.398	.1986	0.352	-0.543	-0.509	.1998	0.168	-0.774	-0.684

* Observer: H. Kučáková.

Table B.27. $UBV(RI)_C$ photometry obtained at Kraków Observatory* (Poland) during and near the 2008/9 eclipse ($E = 10$). The 0.5 m Cassegrain telescope with a CCD camera was used. The differential magnitudes are given with respect to three comparison stars: $a = \text{BD } +55^\circ 2690$, $b = \text{GSC-3973:2150}$, and $c = \text{BD } +55^\circ 2691$. Each point is the mean value obtained from several to tens of frames. The columns labelled $HJD+$ denote the fraction of the day.

	ΔU				ΔB				ΔV				ΔR_C				ΔI_C			
HJD	$HJD+$	$v-a$	$v-b$	$v-c$	$HJD+$	$v-a$	$v-b$	$v-c$	$HJD+$	$v-a$	$v-b$	$v-c$	$HJD+$	$v-a$	$v-b$	$v-c$	$HJD+$	$v-a$	$v-b$	$v-c$
2454751	...	...	...	...	.5043	0.473	-0.305	-0.348	.5045	0.420	-0.424	-0.432	.5046	0.310	-0.582	-0.555	...	...	...	...
2454753	...	...	...	...	.2875	0.466	-0.305	-0.354	.2899	0.415	-0.424	-0.430	.2954	0.308	-0.581	-0.556	...	...	...	...
2454761	.3144	0.091	-0.381	-0.483	.3174	0.455	-0.293	-0.341	.3185	0.393	-0.458	-0.454	.3195	0.295	-0.599	-0.565	.3203	0.124	-0.821	-0.732
2454762	...	...	...	...	.2463	0.465	-0.290	-0.340	.2505	0.396	-0.459	-0.457	.2533	0.297	-0.603	-0.569	...	...	...	...
2454766	...	...	...	...	.3773	0.449	-0.301	-0.352	.3795	0.385	-0.472	-0.468	.3820	0.287	-0.623	-0.582	.3788	0.122	-0.826	-0.739
2454773	...	...	...	...	.4528	0.479	-0.292	-0.345	.4516	0.432	-0.413	-0.426	.4478	0.311	-0.587	-0.558	...	...	...	...
2454780	...	...	...	...	.2080	0.478	-0.295	-0.345	.2081	0.428	-0.417	-0.431	.2089	0.316	-0.576	-0.551	...	...	...	...
2454781	...	...	...	...	.2612	0.470	-0.294	-0.349	.2611	0.425	-0.416	-0.429	.2614	0.316	-0.575	-0.552	...	...	...	...
2454782	...	...	...	...	.4971	0.477	-0.301	-0.345	.4969	0.419	-0.421	-0.433	.4973	0.307	-0.590	-0.565	...	...	...	...
2454786	...	...	...	...	.2532	0.471	-0.293	-0.358	.2571	0.417	-0.422	-0.433	.2590	0.304	-0.587	-0.559	...	...	...	...
2454795	...	...	...	...	.2542	0.477	-0.292	-0.344	.2585	0.434	-0.402	-0.419	.2504	0.323	-0.570	-0.546	...	...	...	...
2454799	.1689	0.104	-0.360	-0.474	.1725	0.472	-0.272	-0.332	.1731	0.403	-0.445	-0.446	.1731	0.305	-0.586	-0.554	.1729	0.132	-0.811	-0.721
2454807	...	...	...	...	.1906	0.486	-0.267	-0.320	.1909	0.420	-0.437	-0.438	.1910	0.323	-0.578	-0.548	.1911	0.148	-0.804	-0.709
2454814	...	...	...	...	.2001	0.516	-0.248	-0.304	.2004	0.458	-0.385	-0.389	.2006	0.348	-0.547	-0.516	...	...	...	...
2454816	.2096	0.151	-0.311	-0.425	.2100	0.502	-0.245	-0.304	.2103	0.437	-0.419	-0.420	.2105	0.341	-0.558	-0.529	.2103	0.162	-0.789	-0.702
2454824	.2160	0.165	-0.300	-0.410	.1902	0.514	-0.237	-0.291	.1912	0.444	-0.417	-0.409	.1898	0.348	-0.553	-0.516	.1903	0.170	-0.778	-0.685
2454830	.3385	0.327	-0.130	-0.230	.3572	0.667	-0.084	-0.137	.3491	0.566	-0.289	-0.286	.3494	0.456	-0.441	-0.404	.3589	0.265	-0.680	-0.590
2454831	.3318	0.389	-0.089	-0.194	.3328	0.703	-0.095	-0.045	.3329	0.600	-0.253	-0.249	.3337	0.488	-0.411	-0.379	.3330	0.295	-0.655	-0.559
2454832	.2844	0.381	-0.091	-0.206	.2854	0.697	-0.055	-0.108	.2844	0.599	-0.260	-0.259	.2861	0.483	-0.414	-0.382	.2848	0.294	-0.653	-0.563
2454834	.3050	0.360	-0.102	-0.210	.3056	0.686	-0.064	-0.118	.3059	0.594	-0.264	-0.265	.3064	0.484	-0.417	-0.387	.3069	0.294	-0.655	-0.563
2454835	.2493	0.323	-0.132	-0.235	.2497	0.670	-0.083	-0.134	.2507	0.585	-0.272	-0.271	.2506	0.478	-0.416	-0.383	.2508	0.297	-0.655	-0.564
2454840	.2018	0.565	0.099	0.000	.2026	0.904	0.155	0.099	.2028	0.800	-0.054	-0.051	.2029	0.682	-0.214	-0.184	.2031	0.470	-0.475	-0.385
2454841	.2219	0.596	0.132	0.023	.2224	0.941	0.192	0.130	.2226	0.838	-0.026	-0.028	.2228	0.712	-0.198	-0.165	.2230	0.498	-0.457	-0.361
2454843	.2471	0.604	0.137	0.020	.2484	0.924	0.174	0.119	.2486	0.827	-0.033	-0.033	.2478	0.702	-0.191	-0.165	.2489	0.495	-0.445	-0.365
2454844	.2223	0.550	0.080	-0.016	.2260	0.882	0.137	0.082	.2284	0.787	-0.066	-0.067	.2298	0.673	-0.222	-0.191	.2308	0.471	-0.478	-0.387
2454845	.2407	0.495	0.041	-0.073	.2413	0.830	0.083	0.026	.2414	0.742	-0.091	-0.105	.2416	0.634	-0.259	-0.230	.2418	0.430	-0.508	-0.416
2454850	.2349	0.319	-0.176	-0.261	.2357	0.667	-0.081	-0.134	.2360	0.593	-0.263	-0.259	.2368	0.480	-0.420	-0.368	.2363	0.302	-0.647	-0.565
2454851	.2346	0.302	-0.169	-0.268	.3316	0.624	-0.129	-0.184	.2316	0.552	-0.301	-0.299	.2302	0.455	-0.443	-0.414	.2292	0.267	-0.675	-0.589
2454857	.2723	0.145	-0.325	-0.401	.2757	0.517	-0.236	-0.294	.2761	0.459	-0.405	-0.399	.2756	0.352	-0.554	-0.520	.2763	0.169	-0.779	-0.688
2454865	.2306	0.130	-0.332	-0.446	.2383	0.490	-0.262	-0.318	.2387	0.420	-0.439	-0.435	.2398	0.316	-0.583	-0.552	.2383	0.144	-0.804	-0.712
2454882	.2211	0.147	-0.336	-0.438	.2219	0.494	-0.262	-0.311	.2222	0.430	-0.422	-0.416	.2224	0.304	-0.570	-0.539	.2212	0.153	-0.794	-0.698
2454884	.2302	0.128	-0.341	-0.456	.2301	0.492	-0.260	-0.313	.2317	0.426	-0.433	-0.430	.2333	0.318	-0.582	-0.542	.2323	0.141	-0.806	-0.716
2454891	.6501	0.109	-0.351	-0.453	.6512	0.475	-0.277	-0.327	.6521	0.411	-0.444	-0.443	.6519	0.311	-0.586	-0.550	.6519	0.133	-0.814	-0.721

* Observers: E. Kuligowska, T. Kundera, M. Kurpińska-Winiarska, A. Kuźmicz, T. Szymański, M. Winiarski, S. Zoła.

Table B.29. $UBV(RI)_C$ photometry obtained at Piwnice Observatory* (Poland) during and near the 2008/9 eclipse ($E = 10$). The 0.6 m Cassegrain telescope with SBIG STL-1001 CCD camera was used. Differential magnitudes are given with respect to three comparison stars: $a = \text{BD } +55^\circ 2690$, $b = \text{GSC-3973:2150}$, and $c = \text{BD } +55^\circ 2691$. Each point is the mean value obtained from several to tens of frames. The columns labelled $HJD+$ denote the fraction of the day.

	ΔU				ΔB				ΔV				ΔR_c				ΔI_c			
HJD	$HJD+$	$v-a$	$v-b$	$v-c$	$HJD+$	$v-a$	$v-b$	$v-c$	$HJD+$	$v-a$	$v-b$	$v-c$	$HJD+$	$v-a$	$v-b$	$v-c$	$HJD+$	$v-a$	$v-b$	$v-c$
2453545	.4537	0.131	-0.343	-0.429	.4460	0.459	-0.307	-0.367	.4407	0.411	-0.437	-0.452	.4615	0.288	-0.608	-0.579	.4647	0.109	-0.840	-0.746
2453580	.5803	0.163	-0.353	-0.419	.5708	0.439	-0.313	-0.365	.5681	0.394	-0.453	-0.460	.5735	0.294	-0.625	-0.583	.5759	0.106	-0.848	-0.755
2453602	.4483	0.158	-0.349	-0.427	.4395	0.447	-0.306	-0.372	.4365	0.405	-0.442	-0.457	.4531	0.300	-0.605	-0.586	.4545	0.123	-0.830	-0.755
2453613	.5375	0.175	-0.347	-0.437	.5421	0.459	-0.306	-0.370	.5439	0.411	-0.442	-0.459	.5450	0.304	-0.598	-0.578	.5459	0.124	-0.834	-0.751
2453648	.4016	0.163	-0.337	-0.424	.4056	0.456	-0.299	-0.363	.4074	0.419	-0.434	-0.447	.4086	0.303	-0.595	-0.583	.4093	0.121	-0.829	-0.746
2453663	.3733	0.154	-0.341	-0.430	.3709	0.451	-0.299	-0.355	.3699	0.407	-0.426	-0.439	.3716	0.298	-0.585	-0.562	.3721	0.113	-0.816	-0.741
2453745	.2238	0.148	-0.365	-0.449	.2201	0.453	-0.307	-0.363	.2177	0.405	-0.443	-0.456	.2265	0.296	-0.612	-0.578	.2275	0.106	-0.844	-0.755
2453760	.2837	0.226	-0.270	-0.348	.2778	0.468	-0.304	-0.364	.2722	0.415	-0.443	-0.452	.2907	0.295	-0.598	-0.584	.2946	0.110	-0.842	-0.774
2453863	.5217	0.165	-0.338	-0.428	.5134	0.457	-0.308	-0.365	.5071	0.402	-0.439	-0.452	.5045	0.291	-0.603	-0.574	.5031	0.104	-0.833	-0.750
2453868	...	...	...	...	...	...	...	...	.5313	0.347	-0.514	-0.473	.5305	0.275	-0.616	-0.575	.5293	0.096	-0.833	-0.750
2453899	.4656	0.161	-0.360	-0.437	.4608	0.471	-0.295	-0.362	.4569	0.433	-0.421	-0.452	.4702	0.290	-0.609	-0.577	.4719	0.112	-0.835	-0.751
2453940	.4096	0.164	-0.357	-0.432	.4029	0.468	-0.297	-0.364	.3978	0.429	-0.425	-0.454	.4163	0.296	-0.602	-0.580	.4179	0.112	-0.842	-0.758
2453983	.4526	0.186	-0.330	-0.411	.4478	0.456	-0.302	-0.358	.4435	0.396	-0.452	-0.456	.4417	0.313	-0.594	-0.574	.4399	0.120	-0.832	-0.753
2454024	.4313	0.188	-0.324	-0.413	.4273	0.450	-0.315	-0.357	.4249	0.394	-0.452	-0.450	.4355	0.305	-0.594	-0.568	.4375	0.115	-0.829	-0.743
2454128	.3870	0.169	-0.333	-0.401	.3918	0.436	-0.303	-0.354	.3795	0.393	-0.443	-0.446	.3991	0.291	-0.592	-0.568	.4012	0.114	-0.832	-0.748
2454249	.4816	0.165	-0.377	-0.400	.4730	0.492	-0.287	-0.354	.4709	0.442	-0.412	-0.438	.4755	0.308	-0.594	-0.574	.4772	0.113	-0.836	-0.741
2454290	.5118	0.177	-0.353	-0.417	.5058	0.483	-0.286	-0.355	.4974	0.437	-0.414	-0.431	.5007	0.300	-0.600	-0.564	.5032	0.110	-0.842	-0.740
2454321	.4035	0.155	-0.363	-0.431	.3989	0.497	-0.270	-0.345	.3952	0.431	-0.420	-0.437	.4075	0.298	-0.599	-0.559	.4092	0.116	-0.840	-0.734
2454382	.4395	0.172	-0.346	-0.392	.4301	0.456	-0.295	-0.359	.4271	0.417	-0.426	-0.453	.4329	0.305	-0.585	-0.568	.4352	0.133	-0.815	-0.733
2454407	.3093	0.159	-0.358	-0.436	.2999	0.453	-0.310	-0.357	.2968	0.404	-0.440	-0.442	.3032	0.299	-0.601	-0.564	.3044	0.113	-0.839	-0.740
2454530	...	...	...	...	.2293	0.460	-0.306	-0.355	.2323	0.413	-0.436	-0.437	.2351	0.299	-0.608	-0.576	.2365	0.132	-0.827	-0.754
2454536	...	...	...	...	.2699	0.461	-0.316	-0.356	.2668	0.404	-0.451	-0.453	.2727	0.292	-0.604	-0.570	.2743	0.124	-0.837	-0.760
2454571	.5846	0.186	-0.336	-0.415	.5795	0.467	-0.302	-0.352	.5777	0.418	-0.429	-0.433	.5890	0.304	-0.600	-0.567	.5907	0.126	-0.831	-0.734
2454606	.4481	0.173	-0.339	-0.419	.4439	0.459	-0.308	-0.361	.4387	0.403	-0.439	-0.448	.4405	0.291	-0.608	-0.575	.4418	0.113	-0.838	-0.740
2454648	.4318	0.171	-0.340	-0.428	.4281	0.460	-0.297	-0.353	.4228	0.408	-0.434	-0.442	.4249	0.300	-0.593	-0.561	.4261	0.120	-0.819	-0.731
2454621	...	...	...	...	.3847	0.466	-0.303	-0.358	.3805	0.399	-0.437	-0.449	.3752	0.289	-0.600	-0.568	.3665	0.122	-0.822	-0.741
2454662	.4231	0.178	-0.347	-0.435	.4125	0.463	-0.299	-0.354	.4096	0.409	-0.430	-0.438	.4157	0.311	-0.582	-0.572	.4183	0.129	-0.822	-0.736
2454677	.4145	0.177	-0.341	-0.424	.4064	0.455	-0.308	-0.357	.4045	0.411	-0.440	-0.450	.4096	0.301	-0.598	-0.574	.4110	0.131	-0.827	-0.744
2454700	...	...	...	...	.3964	0.465	-0.284	-0.342	.3939	0.425	-0.417	-0.432	.4001	0.313	-0.580	-0.557	.4041	0.139	-0.809	-0.727
2454720	.4889	0.179	-0.330	-0.412	.4840	0.467	-0.292	-0.344	.4827	0.415	-0.424	-0.439	.4853	0.312	-0.594	-0.581	.4862	0.148	-0.824	-0.731
2454734	.5773	...	-0.362	-0.423	.5725	0.451	-0.312	-0.355	.5707	0.415	-0.441	-0.444	.5747	0.290	-0.610	-0.570	.5759	0.109	-0.840	-0.737
2454735	.2914	0.178	-0.325	-0.414	.2875	0.481	-0.274	-0.338	.2830	0.434	-0.430	-0.441	.2845	0.320	-0.578	-0.571	.2856	0.139	-0.809	-0.736
2454742	.2763	0.189	-0.333	-0.411	.2725	0.483	-0.278	-0.336	.2700	0.437	-0.415	-0.443	.2801	0.321	-0.577	-0.561	.2812	0.135	-0.810	-0.732
2454750	.2490	0.198	-0.322	-0.422	.2430	0.470	-0.287	-0.347	.2395	0.427	-0.430	-0.435	.2569	0.329	-0.580	-0.574	.2591	0.155	-0.806	-0.743
2454757	.2543	0.178	-0.335	-0.427	.2435	0.475	-0.282	-0.343	.2441	0.420	-0.430	-0.433	.2492	0.319	-0.584	-0.564	.2514	0.141	-0.804	-0.738
2454763	.2014	0.176	-0.337	-0.414	.2047	0.466	-0.294	-0.348	.2077	0.419	-0.418	-0.442	.2125	0.311	-0.586	-0.562	.2116	0.138	-0.810	-0.733
2454771	.3691	0.187	-0.335	-0.411	.3723	0.461	-0.294	-0.350	.3741	0.432	-0.435	-0.441	.3751	0.316	-0.587	-0.561	.3759	0.137	-0.815	-0.731
2454780	.2116	...	-0.365	-0.383	.2206	0.473	-0.268	-0.327	.2178	0.407	-0.421	-0.427	.2260	0.335	-0.560	-0.561	.2338	0.132	-0.781	-0.725
2454781	...	...	...	...	.1675	...	...	-0.351	.1729	0.426	-0.431	-0.449	...	...	...	...	...	...	...	...
2454782	...	...	...	...	.2186	0.470	-0.284	-0.343	.1968	0.412	-0.425	-0.436	...	...	...	...	...	...	...	...
2454784	.2763	0.190	-0.331	-0.400	.2687	0.477	-0.284	-0.334	.2657	0.432	-0.417	-0.430	.2726	0.320	-0.588	-0.555	.2713	0.136	-0.826	-0.728
2454793	.3080	0.170	-0.333	-0.431	.3014	0.457	-0.296	-0.343	.2986	0.416	-0.427	-0.432	.3033	0.307	-0.588	-0.560	.3045	0.134	-0.816	-0.731
2454801	.2991	0.196	-0.311	-0.426	.2899	0.487	-0.266	-0.322	.2742	0.433	-0.427	-0.426	.2927	0.328	-0.574	-0.547	.2943	0.149	-0.810	-0.721
2454804	.1929	0.189	-0.322	-0.403	.1806	0.494	-0.266	-0.335	.1776	0.445	-0.416	-0.436	.1867	0.329	-0.567	-0.551	.1843	0.142	-0.805	-0.729
2454810	.3225	0.211	-0.287	-0.361	.3182	0.482	-0.269	-0.319	.3104	0.439	-0.411	-0.416	.3128	0.329	-0.568	-0.535	.3155	0.144	-0.804	-0.709
2454811	...	...	...	...	.1511	0.499	-0.261	-0.319	...	...	...	...	.1453	0.345	-0.561	-0.533	.1476	0.156	-0.800	-0.722
2454814	.3147	0.246	-0.271	-0.365	.3011	0.520	-0.231	-0.304	.2966	0.476	-0.364	-0.392	.3061	0.365	-0.533	-0.511	.3088	0.178	-0.773	-0.688
2454815	.1837	0.244	-0.263	-0.372	.1818	0.527	-0.245	-0.287	.1778	0.456	-0.381	-0.404	.1792	0.355	-0.551	-0.521	.1802	0.153	-0.803	-0.719
2454822	.1843	0.211	-0.298	-0.372	.1736	0.505	-0.250	-0.311	.1610	0.467	-0.387	-0.397	.1681	0.348	-0.558	-0.529	.1649	0.162	-0.796	-0.707
2454824	.1751	0.222	-0.272	-0.368	.1676	0.515	-0.247	-0.294	.1612	0.457	-0.395	-0.390	.1658	0.358	-0.544	-0.512	.1639	0.178	-0.775	-0.689
2454830	.1785	0.403	-0.140	-0.215	.1723	0.635	-0.075	-0.131	.1709	0.582	-0.245	-0.269	.1754	0.461	-0.431	-0.406	.1766	0.273	-0.661	-0.591

Table B.29. continued.

	ΔU				ΔB				ΔV				ΔR_c				ΔI_c			
<i>HJD</i>	<i>HJD</i> +	<i>v</i> - <i>a</i>	<i>v</i> - <i>b</i>	<i>v</i> - <i>c</i>	<i>HJD</i> +	<i>v</i> - <i>a</i>	<i>v</i> - <i>b</i>	<i>v</i> - <i>c</i>	<i>HJD</i> +	<i>v</i> - <i>a</i>	<i>v</i> - <i>b</i>	<i>v</i> - <i>c</i>	<i>HJD</i> +	<i>v</i> - <i>a</i>	<i>v</i> - <i>b</i>	<i>v</i> - <i>c</i>	<i>HJD</i> +	<i>v</i> - <i>a</i>	<i>v</i> - <i>b</i>	<i>v</i> - <i>c</i>
2454831	.1749	0.455	-0.075	-0.111	.1694	0.697	-0.045	-0.097	.1671	0.630	-0.221	-0.223	.1715	0.497	-0.398	-0.370	.1723	0.272	-0.667	-0.564
2454834	.4419	...	...	-0.112	.4379	0.683	-0.076	-0.136	.4365	0.617	-0.233	-0.250	.4389	0.497	-0.403	-0.374	.4395	0.305	-0.657	-0.548
2454837	.3498	0.543	-0.016	-0.042	.3485	0.743	-0.015	-0.068	.3471	0.674	-0.194	-0.187	.3435	0.554	-0.353	-0.319	.3579	0.330	-0.605	-0.528
2454838	.3027	0.568	0.011	-0.013	.2993	0.782	0.033	-0.026	.3053	0.718	-0.138	-0.146	.3052	0.590	-0.306	-0.286	.3047	0.390	-0.565	-0.474
2454839	.3540	0.621	0.098	0.004	.3465	0.847	0.090	0.039	.3399	0.800	-0.056	-0.078	.3422	0.655	-0.244	-0.214	.3433	0.463	-0.499	-0.413
2454840	...	...	...	...	.4393	0.928	0.184	0.081	.4408	0.829	0.006	-0.045	.4412	0.673	-0.208	-0.182	.4417	0.482	-0.466	-0.380
2454843	.2597	0.676	0.128	0.070	.2403	0.954	0.166	0.144	.2333	0.875	0.020	-0.002	.2473	0.726	-0.195	-0.149	.2510	0.505	-0.481	-0.372
2454844	.1798	0.660	0.112	0.057	.1846	0.884	0.130	0.060	.1874	0.829	-0.024	-0.046	.1898	0.694	-0.203	-0.180	.1920	0.481	-0.472	-0.387
2454845	.2835	0.570	0.050	-0.023	.2697	0.852	0.095	0.038	.2724	0.771	-0.075	-0.092	.2749	0.647	-0.251	-0.228	.2772	0.452	-0.502	-0.443
2454849	.2648	0.499	-0.093	-0.122	.2600	0.715	-0.059	-0.108	.2510	0.644	-0.212	-0.226	.2539	0.531	-0.389	-0.344	.2559	0.326	-0.656	-0.543
2454851	.1954	0.372	-0.148	-0.227	.1879	0.630	-0.121	-0.176	.1926	0.582	-0.267	-0.273	.1913	0.467	-0.430	-0.400	.1903	0.262	-0.675	-0.586
2454860	.2508	0.218	-0.307	-0.399	.2458	0.504	-0.259	-0.317	.2455	0.454	-0.402	-0.411	...	...	...	...	.2456	0.167	-0.792	-0.714
2454865	.2111	0.218	-0.280	-0.367	.2170	0.484	-0.263	-0.318	.2200	0.448	-0.401	-0.410	.2224	0.334	-0.563	-0.538	.2248	0.144	-0.802	-0.714
2454872	.2273	0.202	-0.313	-0.380	.2169	0.492	-0.270	-0.325	.2227	0.445	-0.405	-0.414	.2210	0.331	-0.578	-0.541	.2192	0.148	-0.814	-0.718
2454878	.2197	0.222	-0.283	-0.363	.2331	0.519	-0.240	-0.296	.2308	0.461	-0.409	-0.400	.2287	0.344	-0.555	-0.532	.2260	0.164	-0.796	-0.695
2454881	...	...	...	...	.2281	0.500	-0.254	-0.305	...	...	...	...	...	...	...	...	.2287	0.139	-0.804	-0.736
2454883	.2266	0.225	-0.316	-0.374	.2262	0.501	-0.267	-0.316	.2264	0.453	-0.405	-0.408	.2276	0.332	-0.579	-0.541	.2278	0.144	-0.812	-0.726
2454884	.2390	0.198	-0.309	-0.383	.2391	0.502	-0.259	-0.313	.2390	0.449	-0.402	-0.411	.2383	0.319	-0.554	-0.523	.2390	0.152	-0.800	-0.710
2454891	.2865	0.204	-0.324	-0.394	.2717	0.481	-0.282	-0.341	.2807	0.439	-0.416	-0.434	.2794	0.321	-0.581	-0.552	.2741	0.142	-0.818	-0.729
2454903	.2480	0.197	-0.326	-0.414	.2412	0.476	-0.292	-0.334	.2390	0.422	-0.437	-0.440	.2431	0.310	-0.596	-0.568	.2442	0.128	-0.817	-0.721
2454909	.2744	0.179	-0.349	-0.418	.2697	0.469	-0.290	-0.341	.2651	0.417	-0.426	-0.438	.2670	0.316	-0.579	-0.546	.2682	0.121	-0.809	-0.723
2454922	.5776	0.171	-0.319	-0.431	.5723	0.467	-0.302	-0.357	.5705	0.435	-0.424	-0.432	.5739	0.315	-0.582	-0.559	.5751	0.129	-0.834	-0.743
2454938	.5187	0.170	-0.365	-0.409	.5131	0.459	-0.291	-0.351	.5110	0.402	-0.431	-0.442	.5151	0.294	-0.585	-0.559	.5162	0.112	-0.827	-0.729
2454950	.5827	0.182	-0.320	-0.406	.5794	0.465	-0.299	-0.356	.5746	0.436	-0.410	-0.425	.5763	0.303	-0.591	-0.569	.5777	0.129	-0.827	-0.731
2455017	.4503	0.145	-0.357	-0.439	.4374	0.457	-0.323	-0.364	.4330	0.399	-0.450	-0.446	.4415	0.279	-0.617	-0.581	.4397	0.112	-0.835	-0.742
2455027	.4991	0.151	-0.358	-0.420	.4951	0.461	-0.312	-0.357	.4938	0.404	-0.437	-0.443	.4962	0.288	-0.602	-0.556	.4967	0.112	-0.828	-0.746
2455040	.3724	0.184	-0.363	-0.437	...	...	...	...	.3480	0.420	-0.430	-0.435	...	...	...	...	...	...	...	...
2455063	.3655	0.186	-0.351	-0.417	.3580	0.427	-0.319	-0.348	.3561	0.426	-0.419	-0.456	.3602	0.282	-0.612	-0.579	.3613	0.129	-0.815	-0.739
2455083	.3257	0.168	-0.342	-0.402	...	...	...	...	.3030	0.405	-0.434	-0.452	.3040	0.287	-0.606	-0.575	.3051	0.109	-0.830	-0.738
2455099	.4112	0.158	-0.351	-0.444	.4065	0.425	-0.305	-0.353	.4048	0.412	-0.433	-0.442	.4081	0.291	-0.598	-0.574	.4087	0.110	-0.833	-0.733
2455111	.2620	0.156	-0.335	-0.422	.2521	0.445	-0.291	-0.342	.2492	0.427	-0.428	-0.459	.2567	0.301	-0.588	-0.565	.2548	0.146	-0.811	-0.719
2455120	.2429	0.161	-0.356	-0.431	.2319	0.455	-0.306	-0.355	.2289	0.414	-0.441	-0.440	.2347	0.298	-0.601	-0.565	.2368	0.117	-0.835	-0.744
2455138	.2370	0.169	-0.362	-0.426	.2298	0.452	-0.318	-0.360	.2262	0.399	-0.443	-0.451	.2239	0.287	-0.606	-0.574	.2217	0.105	-0.836	-0.745
2455150	.2016	0.168	-0.345	-0.423	.1954	0.441	-0.314	-0.367	.1922	0.399	-0.454	-0.459	.1893	0.284	-0.618	-0.584	.1871	0.102	-0.854	-0.754
2455156	.2812	0.142	-0.411	-0.446	.2775	0.458	-0.308	-0.357	.2762	0.411	-0.444	-0.453	.2784	0.298	-0.604	-0.569	.2789	0.101	-0.850	-0.736
2455162	.3936	0.171	-0.344	-0.396	.3884	0.458	-0.305	-0.358	.3854	0.416	-0.438	-0.445	.3825	0.299	-0.600	-0.573	.3806	0.115	-0.834	-0.744
2455164	.1918	0.166	-0.354	-0.427	.1857	0.465	-0.303	-0.353	.1838	0.418	-0.441	-0.448	.1879	0.300	-0.603	-0.571	.1890	0.111	-0.843	-0.751
2455210	.2149	0.142	-0.390	-0.391	.2067	0.443	-0.309	-0.362	.2045	0.397	-0.447	-0.454	.2085	0.281	-0.618	-0.585	.2124	0.091	-0.872	-0.753
2455233	...	...	...	...	.2330	0.444	-0.315	-0.361	.2305	0.401	-0.448	-0.451	.2285	0.272	-0.622	-0.585	.2271	0.086	-0.864	-0.759
2455253	.2667	0.172	-0.346	-0.468	.2605	0.453	-0.328	-0.377	.2547	0.402	-0.470	-0.465	.2512	0.269	-0.645	-0.606	.2456	0.078	-0.883	-0.785
2455264	...	...	...	...	.2437	0.452	-0.317	-0.369	.2462	0.395	-0.450	-0.454	.2479	0.284	-0.614	-0.590	.2506	0.081	-0.872	-0.774
2455267	...	...	...	...	.2491	0.438	-0.323	-0.377	.2467	0.397	-0.446	-0.461	.2515	0.275	-0.618	-0.589	.2529	0.090	-0.865	-0.773
2455270	...	...	...	...	.6493	0.438	-0.315	-0.361	.6471	0.389	-0.450	-0.456	.6513	0.266	-0.616	-0.585	.6526	0.075	-0.866	-0.767
2455271	...	...	...	...	.2712	0.446	-0.318	-0.367	.2684	0.396	-0.455	-0.462	.2734	0.261	-0.623	-0.596	.2749	0.086	-0.862	-0.771
2455272	...	...	...	...	.2729	0.454	-0.309	-0.361	.2700	0.401	-0.442	-0.447	.2757	0.275	-0.613	-0.584	.2781	0.083	-0.860	-0.770
2455274	.2602	0.163	-0.348	-0.415	.2520	0.447	-0.332	-0.370	.2545	0.404	-0.443	-0.457	.2560	0.272	-0.632	-0.592	.2487	0.088	-0.871	-0.777
2455294	...	...	...	...	.5304	0.449	-0.310	-0.365	.5282	0.401	-0.447	-0.457	.5328	0.283	-0.620	-0.587	...	...	...	...
2455303	.5519	0.157	-0.366	-0.430	.5448	0.461	-0.317	-0.371	.5420	0.412	-0.448	-0.452	.5473	0.284	-0.623	-0.586	.5490	0.093	-0.867	-0.765
2455311	.5037	0.162	-0.356	-0.436	.4953	0.458	-0.313	-0.368	.4929	0.404	-0.449	-0.459	.4977	0.283	-0.620	-0.589	.4993	0.088	-0.876	-0.771

* Observers: P. Dobierski, S. Frąckowiak, C. Gałań, G. Maciejewski, P. Różański, E. Świerczyński, M. Więcek, P. Wychudziński.

Table B.30. $UBV(RI)_C$ photometry obtained at Suhora Observatory* (Poland) during and near the 2008/9 eclipse ($E = 10$). The 0.6 m Cassegrain telescope with a CCD camera was used. The differential magnitudes are given with respect to three comparison stars: $a = \text{BD } +55^\circ 2690$, $b = \text{GSC-3973:2150}$, and $c = \text{BD } +55^\circ 2691$. Each point is the mean value obtained from several to tens of frames. The columns labelled $HJD+$ denote the fraction of the day.

	ΔU				ΔB				ΔV				ΔR_C				ΔI_C			
HJD	$HJD+$	$v-a$	$v-b$	$v-c$	$HJD+$	$v-a$	$v-b$	$v-c$	$HJD+$	$v-a$	$v-b$	$v-c$	$HJD+$	$v-a$	$v-b$	$v-c$	$HJD+$	$v-a$	$v-b$	$v-c$
2454758	...	...	...	...	.6504	0.435	-0.304	-0.363	.6507	0.403	-0.450	-0.451	.6509	0.298	-0.621	-0.576	.6504	0.122	-0.854	-0.746
2454759	...	...	...	...	.5453	0.408	-0.334	-0.376	.5448	0.366	-0.513	-0.469	.5450	0.282	-0.632	-0.563	.5450	0.095	-0.869	-0.744
2454770	...	...	...	...	...	...	...	...	.5888	0.422	-0.446	-0.461	.5886	0.304	-0.602	-0.571	.5898	0.136	-0.825	-0.736
2454774	.5766	0.150	-0.301	-0.424	.5770	0.475	-0.265	-0.340	.5772	0.407	-0.451	-0.458	.5779	0.305	-0.597	-0.575	.5775	0.124	-0.820	-0.729
2454789	.1813	0.086	-0.372	-0.496	.1930	0.451	-0.287	-0.349	.1932	0.401	-0.456	-0.457	.1933	0.300	-0.599	-0.564	.1933	0.117	-0.828	-0.733
2454798	...	...	...	...	.1804	0.447	-0.289	-0.344	.1807	0.403	-0.457	-0.459	.1804	0.300	-0.600	-0.565	.1811	0.118	-0.834	-0.737
2454799	...	...	...	...	.1689	0.460	-0.260	-0.335	.1699	0.408	-0.442	-0.450	.1701	0.308	-0.583	-0.556	.1705	0.125	-0.813	-0.727
2454800	.3391	0.174	-0.328	-0.428	.3390	0.475	-0.265	-0.332	.3399	0.408	-0.452	-0.452	.3405	0.303	-0.596	-0.565	.3401	0.121	-0.827	-0.736
2454801	.3963	0.088	-0.388	-0.504	.3960	0.471	-0.270	-0.335	.3963	0.413	-0.448	-0.452	.3965	0.313	-0.587	-0.554	.3967	0.135	-0.814	-0.729
2454802	.3645	0.092	-0.380	-0.487	.3648	0.454	-0.285	-0.338	.3651	0.410	-0.456	-0.451	.3635	0.302	-0.600	-0.559	.3654	0.124	-0.830	-0.730
2454803	.1750	0.091	-0.359	-0.478	.1758	0.462	-0.273	-0.330	.1772	0.414	-0.447	-0.447	.1769	0.313	-0.589	-0.553	.1767	0.132	-0.816	-0.722
2454804	.1658	0.085	-0.363	-0.484	.1662	0.457	-0.277	-0.336	.1664	0.409	-0.450	-0.453	.1676	0.308	-0.591	-0.559	.1667	0.125	-0.824	-0.730
2454807	.1758	0.101	-0.354	-0.470	.1769	0.464	-0.267	-0.324	.1771	0.418	-0.440	-0.438	.1772	0.314	-0.584	-0.547	.1774	0.133	-0.815	-0.720
2454810	.1602	0.108	-0.336	-0.462	.1606	0.469	-0.259	-0.314	.1610	0.419	-0.433	-0.435	.1617	0.319	-0.577	-0.539	.1612	0.135	-0.809	-0.717
2454814	.1777	0.145	-0.309	-0.430	.1789	0.503	-0.228	-0.294	.1787	0.446	-0.414	-0.417	.1788	0.343	-0.553	-0.523	.1789	0.154	-0.790	-0.702
2454815	.2924	0.146	-0.316	-0.431	.2932	0.501	-0.235	-0.296	.2934	0.453	-0.412	-0.414	.2923	0.342	-0.559	-0.529	.2924	0.152	-0.800	-0.701
2454816	.1743	0.135	-0.320	-0.441	.1743	0.493	-0.243	-0.307	.1742	0.444	-0.418	-0.426	.1752	0.334	-0.563	-0.534	.1753	0.158	-0.790	-0.698
2454817	...	...	...	...	.2193	0.511	-0.218	-0.284	.2203	0.453	-0.410	-0.410	.2250	0.343	-0.557	-0.528	.2251	0.158	-0.790	-0.700
2454828	.4590	0.297	-0.196	-0.296	.4599	0.569	-0.182	-0.242	.4602	0.484	-0.377	-0.373	.4604	0.376	-0.527	-0.482	.4606	0.199	-0.756	-0.658
2454829	.2105	0.264	-0.174	-0.289	.2107	0.603	-0.124	-0.195	.2118	0.520	-0.330	-0.336	.2114	0.416	-0.471	-0.449	.2121	0.222	-0.706	-0.632
2454830	.3338	0.338	-0.123	-0.241	.3361	0.660	-0.075	-0.134	.3365	0.573	-0.285	-0.285	.3366	0.457	-0.450	-0.408	.3368	0.247	-0.704	-0.595
2454831	.2614	0.370	-0.084	-0.204	.2667	0.698	-0.040	-0.100	.2682	0.605	-0.258	-0.258	.2692	0.488	-0.417	-0.383	.2696	0.282	-0.667	-0.571
2454832	.1930	0.355	-0.077	-0.208	.1939	0.680	-0.044	-0.108	.1942	0.600	-0.250	-0.259	.1956	0.485	-0.404	-0.379	.1946	0.287	-0.652	-0.567
2454835	.1906	0.328	-0.121	-0.248	.1912	0.654	-0.083	-0.132	.1914	0.581	-0.279	-0.269	.1915	0.463	-0.439	-0.383	.1916	0.270	-0.681	-0.562
2454838	.2140	0.431	-0.008	-0.123	.2138	0.767	0.041	-0.017	.2140	0.688	-0.159	-0.160	.2141	0.577	-0.317	-0.281	.2139	0.380	-0.564	-0.470
2454840	.2584	0.569	0.104	-0.013	.2583	0.897	0.165	0.099	.2588	0.809	-0.054	-0.054	.2585	0.684	-0.215	-0.185	.2590	0.471	-0.474	-0.384
2454840	.3564	0.683	0.335	0.122	.3573	0.935	0.201	0.121	.3575	0.817	-0.046	-0.055	.3576	0.692	-0.217	-0.182	.3577	0.483	-0.470	-0.378
2454841	.2628	0.588	0.136	0.018	.2637	0.928	0.192	0.128	.2560	0.837	-0.025	-0.031	.2641	0.712	-0.189	-0.159	.2642	0.492	-0.457	-0.363
2454842	.3841	0.728	0.259	0.070	.3849	0.956	0.209	0.138	.3851	0.848	-0.019	-0.025	.3852	0.729	-0.189	-0.163	.3854	0.490	-0.464	-0.364
2454843	.1863	0.580	0.127	0.006	.1880	0.914	0.187	0.120	.1874	0.828	-0.027	-0.033	.1824	0.705	-0.192	-0.161	.1876	0.488	-0.457	-0.365
2454844	.3335	0.544	0.079	-0.041	.3330	0.879	0.141	0.074	.3332	0.759	-0.095	-0.075	.3371	0.685	-0.229	-0.192	.3335	0.470	-0.479	-0.393
2454845	.1773	0.497	-0.045	-0.084	.1927	0.818	0.095	0.031	.1927	0.754	-0.105	-0.116	.1929	0.625	-0.262	-0.233	.1931	0.432	-0.509	-0.418
2454850	.2687	0.319	-0.143	-0.251	.2696	0.660	-0.073	-0.133	.2699	0.593	-0.261	-0.259	.2713	0.488	-0.411	-0.372	.2702	0.290	-0.652	-0.560
2454851	.3549	0.336	-0.126	-0.233	.3558	0.633	-0.125	-0.186	.3566	0.555	-0.311	-0.313	.3561	0.454	-0.454	-0.422	.3562	0.263	-0.699	-0.605
2454855	.2659	0.197	-0.242	-0.386	.2668	0.524	-0.209	-0.268	.2658	0.475	-0.389	-0.394	.2659	0.360	-0.546	-0.505	.2661	0.183	-0.776	-0.678
2454858	.3938	0.149	-0.309	-0.431	.3945	0.512	-0.238	-0.308	.3967	0.471	-0.397	-0.425	...	...	...	...	...	...	...	...
2454858	.6764	0.152	-0.304	-0.430	.6780	0.498	-0.244	-0.309	.6776	0.440	-0.421	-0.430	.6777	0.332	-0.563	-0.538	.6778	0.157	-0.794	-0.701
2454865	.2305	0.137	-0.302	-0.421	.2311	0.490	-0.246	-0.314	.2313	0.421	-0.435	-0.435	.2315	0.319	-0.578	-0.549	.2316	0.140	-0.804	-0.718
2454868	.2307	0.130	-0.336	-0.454	.2321	0.481	-0.256	-0.317	.2314	0.431	-0.432	-0.435	.2316	0.329	-0.574	-0.544	.2317	0.143	-0.808	-0.715
2454869	.2276	0.111	-0.344	-0.457	.2285	0.466	-0.268	-0.327	.2288	0.410	-0.453	-0.447	.2290	0.306	-0.597	-0.551	.2291	0.097	-0.846	-0.732
2454872	.6515	0.117	-0.344	-0.471	.6524	0.485	-0.263	-0.316	.6532	0.419	-0.448	-0.449	.6540	0.312	-0.592	-0.556	.6528	0.133	-0.819	-0.724

Observers: M. Drózd, J. Krzesiński, W. Ogłóza, M. Siwak, M. Winiarski, S. Zoła.

Table B.31. BVI_C photometry obtained at GRAS Observatory* (Mayhill, New Mexico, USA) during the 2008/9 eclipse ($E = 10$). The 0.3 m GRAS-001 Telescope with an FLI IMG 1024 DM CCD camera was used. Differential magnitudes are given with respect to three comparison stars: $a = \text{BD } +55^\circ 2690$, $b = \text{GSC-3973:2150}$, and $c = \text{BD } +55^\circ 2691$. The columns labelled $HJD+$ denote the fraction of the day.

HJD	ΔB				ΔV				ΔI_C			
	$HJD+$	$v-a$	$v-b$	$v-c$	$HJD+$	$v-a$	$v-b$	$v-c$	$HJD+$	$v-a$	$v-b$	$v-c$
2454816	.63926	0.502	-0.249	-0.314	.63520	0.456	-0.402	-0.393	...	...	...	...
2454821	.58581	0.518	-0.246	-0.302	.58205	0.450	-0.417	-0.423	.58963	0.173	-0.784	-0.681
2454822	.59271	0.526	-0.214	-0.281	.58891	0.438	-0.412	-0.420	.59650	0.170	-0.783	-0.696
2454825	.63850	0.512	-0.235	-0.308	.63147	0.446	-0.408	-0.422	.64524	0.188	-0.756	-0.689
2454828	.60494	0.514	-0.223	-0.310	.59898	0.497	-0.362	-0.378	...	...	...	...
2454829	.70329	0.629	-0.114	-0.187	.69616	0.528	-0.325	-0.350	.65538	0.239	-0.707	-0.634
2454830	.60893	0.651	-0.100	-0.162	.60199	0.567	-0.290	-0.309	.61564	0.276	-0.669	-0.605
2454831	.60554	0.675	-0.076	-0.142	.59850	0.577	-0.279	-0.301	.61225	0.301	-0.657	-0.589
2454832	.59797	0.708	-0.039	-0.119	.59102	0.592	-0.264	-0.281	.60470	0.305	-0.653	-0.574
2454833	.59704	0.679	-0.059	-0.135	.59008	0.591	-0.266	-0.289	.60378	0.290	-0.661	-0.569
2454834	.57529	0.655	-0.087	-0.150	.56834	0.587	-0.272	-0.288	.58201	0.297	-0.653	-0.576
2454835	.61749	0.680	-0.073	-0.128	.61434	0.611	-0.232	-0.245	.62063	0.308	-0.637	-0.550
2454839	.59620	0.848	0.101	0.037	.58923	0.778	-0.076	-0.080	.60181	0.491	-0.457	-0.423
2454840	.57656	0.935	0.193	0.125	.56960	0.807	-0.045	-0.067	.58327	0.520	-0.435	-0.371
2454841	.56866	0.929	0.178	0.116	.56562	0.847	0.004	-0.009	.57172	0.494	-0.452	-0.376
2454843	.57533	0.905	0.155	0.092	.56830	0.810	-0.048	-0.062	.58206	0.488	-0.460	-0.385
2454844	.57236	0.897	0.141	0.080	.56526	0.786	-0.075	-0.088	.57802	0.492	-0.485	-0.399
2454845	.57694	0.822	0.071	0.013	.56986	0.739	-0.112	-0.138	.58367	0.427	-0.531	-0.440
2454846	.57689	0.823	0.069	-0.004	.56980	0.736	-0.116	-0.142	.58362	0.429	-0.516	-0.448
2454847	.58281	0.754	0.006	-0.060	.58032	0.695	-0.147	-0.158	.58587	0.390	-0.541	-0.470
2454849	.57644	0.683	-0.058	-0.124	.57338	0.629	-0.207	-0.224	.57956	0.310	-0.617	-0.538
2454850	.59034	0.673	-0.082	-0.127	.58326	0.597	-0.254	-0.274	.59704	0.303	-0.632	-0.569
2454851	.58991	0.627	-0.120	-0.183	.58276	0.560	-0.287	-0.306	.59657	0.272	-0.675	-0.605
2454852	.58999	0.605	-0.154	-0.208	.58291	0.548	-0.312	-0.336	.59667	0.253	-0.700	-0.625
2454853	.62551	0.574	-0.187	-0.253	.66065	0.520	-0.343	-0.354	.62100	0.218	-0.728	-0.657
2454855	.57829	0.552	-0.192	-0.263	.58145	0.478	-0.379	-0.400	.57515	0.203	-0.750	-0.678
2454856	.58972	0.558	-0.206	-0.286	.58252	0.487	-0.376	-0.395	.59638	0.194	-0.759	-0.674
2454857	.58990	0.531	-0.217	-0.282	.58281	0.464	-0.406	-0.416	.59656	0.183	-0.777	-0.694
2454859	.59015	0.507	-0.250	-0.314	.58307	0.455	-0.420	-0.430	.59682	0.170	-0.798	-0.704
2454860	.59062	0.514	-0.233	-0.307	.58356	0.451	-0.413	-0.432	.59729	0.149	-0.794	-0.715
2454861	.59023	0.509	-0.245	-0.309	.58312	0.446	-0.420	-0.436	.59691	0.163	-0.788	-0.726
2454862	.58953	0.522	-0.235	-0.304	.58245	0.454	-0.409	-0.431	.59621	0.164	-0.774	-0.712
2454863	.58992	0.512	-0.247	-0.307	.58284	0.447	-0.416	-0.438	.59658	0.157	-0.811	-0.731
2454865	.57222	0.517	-0.246	-0.318	.56513	0.462	-0.404	-0.418	.57888	0.163	-0.795	-0.732
2454866	.58951	0.518	-0.241	-0.306	.58243	0.465	-0.399	-0.420	.59618	0.166	-0.764	-0.708
2454867	.57230	0.516	-0.252	-0.315	.56520	0.465	-0.405	-0.416	.57896	0.154	-0.800	-0.728
2454868	.58957	0.509	-0.256	-0.318	.58249	0.457	-0.408	-0.428	.59623	0.166	-0.801	-0.726
2454869	.57300	0.494	-0.253	-0.301	.56591	0.452	-0.419	-0.427	.57970	0.148	-0.788	-0.716
2454872	.58669	0.495	-0.243	-0.317	.57960	0.457	-0.411	-0.427	.59336	0.153	-0.803	-0.723
2454874	.58378	0.509	-0.252	-0.320	.57669	0.463	-0.406	-0.431	.59044	0.156	-0.794	-0.728
2454875	.58655	0.524	-0.252	-0.266	.57946	0.443	-0.425	-0.431	.59433	0.145	-0.818	-0.722
2454876	.57465	0.528	-0.234	-0.305	.60310	0.451	-0.401	-0.412	.58132	0.173	-0.772	-0.703
2454877	.58635	0.534	-0.227	-0.260	.57927	0.454	-0.403	-0.417	.59302	0.160	-0.791	-0.696

* Observer: G. Myers.

Table B.32. *BV* photometry obtained at Rolling Hills Observatory* (Florida, USA) during the 2008/9 eclipse ($E = 10$). The 0.25 m (10") LX 200 telescope with an SBIG ST-9XE CCD camera was used. Differential magnitudes are given with respect to three comparison stars: $a = \text{BD } +55^\circ 2690$, $b = \text{GSC-3973:2150}$, and $c = \text{BD } +55^\circ 2691$. The columns labelled $JD+$ denote the fraction of the day.

JD	ΔB				ΔV			
	$JD+$	$v-a$	$v-b$	$v-c$	$JD+$	$v-a$	$v-b$	$v-c$
2454800	.6208	0.493	-0.263	-0.314	.6176	0.418	-0.441	-0.443
2454804	.5321	0.488	-0.277	-0.329	.5290	0.417	-0.442	-0.445
2454808	.4982	0.505	-0.247	-0.315	.4955	0.430	-0.429	-0.431
2454810	.6058	0.506	-0.230	-0.299	.6034	0.438	-0.430	-0.426
2454812	.4833	0.486	-0.251	-0.317	.4803	0.426	-0.431	-0.436
2454813	.4903	0.518	-0.230	-0.285	.4861	0.447	-0.411	-0.416
2454817	.6049	0.525	-0.220	-0.288	.6015	0.446	-0.410	-0.416
2454818	.4986	0.503	-0.228	-0.303	.4952	0.440	-0.409	-0.423
2454819	.6167	0.501	-0.248	-0.301	.6133	0.427	-0.426	-0.422
2454820	.4903	0.505	-0.243	-0.306	.4878	0.429	-0.430	-0.432
2454821	.5468	0.512	-0.238	-0.305	.5436	0.439	-0.426	-0.423
2454823	.4836	0.517	-0.224	-0.289	.4807	0.444	-0.412	-0.414
2454824	.6126	0.537	-0.232	-0.285	.6092	0.459	-0.410	-0.414
2454826	.5099	0.548	-0.193	-0.259	.5064	0.467	-0.391	-0.392
2454827	.4889	0.554	-0.196	-0.262	.4852	0.478	-0.376	-0.384
2454828	.4880	0.576	-0.167	-0.225	.4846	0.486	-0.367	-0.371
2454829	.4857	0.628	-0.124	-0.185	.4827	0.536	-0.322	-0.328
2454830	.4986	0.696	-0.058	-0.121	.4952	0.588	-0.277	-0.281
2454831	.4951	0.724	-0.028	-0.089	.4910	0.611	-0.253	-0.252
2454834	.4954	0.691	-0.053	-0.118	.4921	0.592	-0.236	-0.269
2454836	.5827	0.713	-0.026	-0.094	.5793	0.628	-0.226	-0.227
2454837	.5547	0.760	0.016	-0.047	.5002	0.668	-0.202	-0.204
2454838	.4962	0.794	0.062	0.006	.4922	0.707	-0.140	-0.145
2454840	.4888	0.929	0.195	0.125	.4854	0.832	-0.028	-0.035
2454841	.5101	0.943	0.201	0.136	.5060	0.839	-0.016	-0.024
2454842	.4927	0.950	0.208	0.138	.4893	0.844	-0.018	-0.025
2454846	.4969	0.800	0.058	0.003	.4937	0.724	-0.132	-0.135
2454848	.4954	0.728	-0.016	-0.076	.4920	0.653	-0.203	-0.210
2454850	.4966	0.674	-0.077	-0.136	.4932	0.588	-0.270	-0.269
2454853	.5072	0.567	-0.180	-0.243	.5033	0.501	-0.361	-0.360
2454854	.5189	0.559	-0.186	-0.243	.5154	0.485	-0.371	-0.372
2454857	.5015	0.527	-0.232	-0.289	.4980	0.456	-0.411	-0.409
2454860	.5043	0.502	-0.246	-0.302	.5009	0.428	-0.429	-0.437
2454862	.5092	0.489	-0.253	-0.311	.5058	0.432	-0.420	-0.426
2454863	.4949	0.489	-0.255	-0.316	.4915	0.430	-0.437	-0.435
2454866	.5108	0.494	-0.253	-0.310	.5069	0.428	-0.432	-0.432
2454867	.4992	0.487	-0.255	-0.314	.4951	0.412	-0.430	-0.433
2454868	.5066	0.492	-0.264	-0.311	.5027	0.425	-0.434	-0.438
2454869	.5066	0.482	-0.260	-0.325	.5032	0.415	-0.443	-0.438
2454870	.5238	0.481	-0.285	-0.318	.5219	0.420	-0.448	-0.440

* Observer: S. Dvorak.

Table B.33. Shifts onto our reference system (Kraków Observatory) for the photometric data obtained during and near the 2003 eclipse ($E = 9$). The shifts were applied to the differential magnitudes shown in Tables B.2–B.10.

Observatory	country	Tel. type	Diameter	$shift_U$	$shift_B$	$shift_V$	$shift_{R_C}$	$shift_{I_C}$
Athens	Greece	Cassegrain	0.4m	...	-0.034	-0.005	0.000	-0.032
Białków	Poland	Cassegrain	0.6m	...	...	+0.038	...	-0.005
Kraków	Poland	Cassegrain	0.5m	0.0	0.0	0.0	0.0	0.0
Kryoneri	Greece	Cassegrain	1.2m	-0.009	+0.029	+0.037	+0.007	-0.010
Piszkéstető	Hungary	Schmidt	0.6/0.9m	...	+0.013	+0.038	+0.040	-0.002
Piwnice	Poland	Cassegrain	0.6m	+0.009	-0.018	+0.021	+0.053	+0.016
Rozhen	Bulgaria	Ritchey-Chrétien	2m	0.0	0.0	+0.068	0.0	0.0
Rozhen	Bulgaria	Schmidt	0.5/0.7m	...	...	+0.062	...	...
Rozhen	Bulgaria	Cassegrain	0.6m	+0.091	+0.061	+0.032	...	...
Skinakas	Greece	Ritchey-Chrétien	1.3m	-0.036	+0.005	+0.020	+0.007	-0.008

Table B.34. Shifts onto our reference system (Kraków Observatory) for the photometric data obtained during and near the 2008/9 eclipse ($E = 10$). The shifts were applied to the differential magnitudes from Tables B.12–B.23 and reduced to BD +55°2690 average values shown in Tables B.24–B.32.

Observatory	country	Tel. type	Diameter	$shift_U$	$shift_B$	$shift_V$	$shift_{R_C}$	$shift_{I_C}$
Altan, Mt Giant	Czech Republic	Reflector	0.2m	...	-0.025	-0.030	-0.008	-0.020
Athens	Greece	Cassegrain	0.4m	...	-0.004	-0.025	-0.009	-0.022
Białków	Poland	Cassegrain	0.6m	...	+0.004	-0.014	-0.006	-0.022
Green Island	North Cyprus	Ritchey-Chrétien	0.35m	...	-0.001	-0.018	-0.001	-0.031
Hankasalmi	Finland	RCOS	0.4m	...	-0.009	-0.009	-0.012	+0.009
Furzehill, Swansea	United Kingdom	Schmidt-Cassegrain	0.35m	...	+0.013	-0.020	-0.020	-0.036
Kraków	Poland	Cassegrain	0.5m	0.0	0.0	0.0	0.0	0.0
Kryoneri	Greece	Cassegrain	1.2m	...	+0.102	+0.025	+0.005	+0.013
GRAS, Mayhill	USA (NM)	Reflector	0.3m	...	-0.005	-0.011	...	-0.014
Navas de Oro, Segovia	Spain	Reflector	0.35m	...	...	-0.026	...	...
Ostrava	Czech Republic	Newton	0.2m	...	+0.009	-0.016	-0.011	-0.009
Ostrava	Czech Republic	Schmidt-Cassegrain	0.3m	...	+0.013	-0.013	+0.014	+0.011
Piwnice	Poland	Cassegrain	0.6m	-0.080	-0.006	-0.021	-0.014	-0.005
Rolling Hills, Clermont	USA (FL)	Reflector	0.25m	...	-0.006	-0.005	...	...
Rozhen	Bulgaria	Ritchey-Chrétien	2m	...	+0.028	+0.013	+0.012	-0.025
Rozhen	Bulgaria	Schmidt	0.5/0.7m	-0.023	-0.004	-0.024	-0.022	-0.031
Rozhen	Bulgaria	Cassegrain	0.6m	-0.057	-0.012	-0.023	-0.025	-0.008
Sonoita, B. Staels	USA (AZ)	Reflector	0.5m	...	-0.003	-0.019	-0.129	-0.187
Sonoita, HPO	USA (AZ)	Reflector	0.5m	...	-0.007	-0.002	+0.010	-0.014
Suhora	Poland	Cassegrain	0.6m	+0.006	+0.011	-0.000	-0.001	+0.006
Tenagra-II	USA (AZ)	Ritchey-Chrétien	0.81m	-0.084	-0.023	-0.044	-0.021	-0.028

Table B.35. The mean points of the average $UBV(RI)_C$ light curves obtained during and near the 2003 ($E = 9$) and 2008/9 ($E = 10$) eclipses. Magnitudes and the corresponding standard deviations are given. Mean magnitudes were obtained by averaging the data ($var - a$): in the case of the 2003 eclipse from Tables B.2–B.11 and in the case of the 2008/9 eclipse from Tables B.12–B.32. Finally, to obtain magnitudes in the standard Johnson-Cousins photometric system, the comparison star ($a=BD+55^\circ 2690$) magnitudes (according to Mikołajewski et al. (2003)) have been added. The columns labelled $JD+$ denote the fraction of the day.

JD	$JD+$	U	σ_U	N_U	$JD+$	B	σ_B	N_B	$JD+$	V	σ_V	N_V	$JD+$	R_C	σ_{R_C}	N_{R_C}	$JD+$	I_C	σ_{I_C}	N_{I_C}
2452520	.44	10.925	...	1	.44	11.141	...	1	.44	10.824	...	1	.44	10.396	...	1	.44	9.984	...	1
2452528	.48	10.905	...	1	.48	11.111	...	1	.48	10.789	...	1	.48	10.382	...	1	.48	9.976	...	1
2452537	.39	10.884	...	1	.39	11.117	...	1	.39	10.787	...	1	.39	10.375	...	1	.39	9.957	...	1
2452550	.48	10.910	...	1	.48	11.139	...	1	.48	10.805	...	1	.48	10.390	...	1	.48	9.959	...	1
2452567	.44	10.877	...	1	.44	11.092	...	1	.44	10.804	...	1	.44	10.382	...	1	.44	9.971	...	1
2452618	.44	10.918	...	1	.44	11.126	...	1	.44	10.800	...	1	.44	10.400	...	1	.44	9.991	...	1
2452644	.30	10.912	...	1	.30	11.120	...	1	.30	10.799	...	1	.30	10.376	...	1	.30	9.970	...	1
2452706	...	...	...	...	...	...	...	...	...	...	...	...	.32	10.370	...	1	.32	9.967	...	1
2452711	.63	10.891	...	1	.63	11.120	...	1	.63	10.807	...	1	.63	10.388	...	1	.63	9.972	...	1
2452723	.60	10.954	...	1	.60	11.138	...	1	.60	10.829	...	1	.60	10.407	...	1	.60	9.989	...	1
2452739	...	...	...	...	.63	11.134	...	1	.62	10.812	...	1	.62	10.406	...	1	.63	9.982	...	1
2452742	...	...	...	...	.61	11.143	...	1	.61	10.803	...	1	.61	10.400	...	1	.61	10.006	...	1
2452743	...	...	...	...	.61	11.116	...	1	.61	10.802	...	1	.61	10.398	...	1	.61	9.986	...	1
2452744	.61	10.955	...	1	.60	11.146	...	1	.60	10.823	...	1	.60	10.425	...	1	.60	9.991	...	1
2452746	.58	10.961	0.006	2	.59	11.144	0.012	2	.59	10.806	0.003	2	.59	10.405	0.014	2	.58	9.986	0.007	2
2452750	.60	10.979	...	1	.59	11.154	...	1	.59	10.820	...	1	.59	10.416	...	1	.59	9.999	...	1
2452751	.60	10.952	...	1	.59	11.160	...	1	.59	10.829	...	1	.59	10.423	...	1	.59	9.990	...	1
2452754	...	...	...	...	...	...	...	...	.54	10.847	...	1	.54	10.433	...	1	.54	9.970	...	1
2452755	.51	11.000	0.008	2	.52	11.171	0.000	2	.51	10.856	0.017	2	.51	10.431	0.006	2	.52	10.009	0.016	2
2452756	...	...	...	...	...	...	...	...	.49	10.869	...	1	...	...	...	...	...	...	...	...
2452758	...	...	...	...	.59	11.158	...	1	.58	10.823	0.000	2	.59	10.413	...	1	.59	9.999	...	1
2452759	...	...	...	...	...	...	...	...	.59	10.811	...	1	.50	10.428	...	1	...	...	...	...
2452760	.58	10.972	...	1	.58	11.145	...	1	.54	10.824	0.000	2	.50	10.388	...	1	...	...	...	...
2452761	.57	11.030	...	1	.57	11.204	...	1	.57	10.849	...	1	...	...	...	...	...	...	...	...
2452764	.54	10.984	...	1	.60	11.166	0.002	2	.59	10.834	0.005	2	.60	10.422	0.005	2	.59	10.003	0.001	2
2452765	.55	10.969	0.034	2	.55	11.177	0.002	2	.55	10.836	0.010	3	.55	10.413	0.020	3	.55	10.008	0.006	3
2452766	.56	10.983	...	1	.56	11.148	...	1	.56	10.820	...	1	.57	10.417	...	1	.56	10.038	...	1
2452767	.54	11.028	...	1	.55	11.198	...	1	.55	10.859	...	1	.55	10.447	...	1	.55	10.029	...	1
2452769	...	...	...	...	.50	11.201	...	1	.59	10.877	0.013	2	.49	10.447	...	1	.49	10.024	...	1
2452770	...	...	...	...	.57	11.210	...	1	.58	10.866	...	1	.57	10.453	...	1	.58	10.031	...	1
2452771	...	...	...	...	.56	11.212	...	1	.55	10.874	...	1	.55	10.466	...	1	.55	10.035	...	1
2452772	...	...	...	...	.54	11.213	...	1	.54	10.886	...	1	.47	10.459	...	1	.52	10.031	...	1
2452773	...	...	...	...	.57	11.222	...	1	.57	10.884	...	1	.57	10.471	...	1	.57	10.045	...	1
2452774	.51	11.122	...	1	.51	11.254	0.024	2	.51	10.912	0.005	2	.51	10.485	0.006	2	.50	10.067	0.011	2
2452775	...	...	...	...	.48	11.267	...	1	.48	10.917	...	1	.48	10.507	...	1	.47	10.071	...	1
2452776	.52	11.136	0.004	2	.52	11.286	0.002	4	.53	10.936	0.004	5	.52	10.523	0.002	4	.53	10.087	0.003	5
2452777	...	...	...	...	...	...	...	...	.53	10.949	...	1	...	...	...	...	.52	10.109	...	1
2452778	...	...	...	...	.57	11.313	...	1	.54	10.959	0.010	2	.57	10.560	...	1	.57	10.118	...	1
2452779	...	...	...	...	.57	11.353	...	1	.57	11.008	...	1	.57	10.590	...	1	.57	10.138	...	1
2452781	.51	11.202	...	1	.46	11.361	...	1	.57	11.006	0.005	2	.48	10.576	...	1	.48	10.146	...	1
2452782	.45	11.238	...	1	.45	11.363	...	1	.45	11.009	...	1	.45	10.586	...	1	.45	10.139	...	1
2452783	.54	11.248	...	1	.53	11.392	...	1	.53	11.031	...	1	.53	10.597	...	1	.53	10.177	...	1
2452784	.50	11.296	0.004	2	.50	11.453	0.013	2	.52	11.072	0.004	3	.50	10.657	0.007	2	.51	10.225	0.007	3
2452785	.53	11.299	...	1	.52	11.447	...	1	.63	11.085	0.005	2	.52	10.654	...	1	.52	10.238	...	1
2452786	...	...	...	...	.47	11.434	...	1	.49	11.089	...	1	.49	10.667	...	1	.50	10.236	...	1
2452787	.47	11.324	...	1	.47	11.461	...	1	.59	11.130	0.010	2	.47	10.721	...	1	.47	10.275	...	1
2452788	.46	11.363	...	1	.46	11.515	0.017	2	.50	11.168	0.003	3	.46	10.742	0.003	2	.49	10.305	0.003	3
2452789	.50	11.436	0.014	2	.50	11.609	0.004	2	.62	11.239	0.014	3	.50	10.794	0.017	2	.50	10.371	0.025	2
2452790	.50	11.505	0.013	2	.49	11.675	0.007	2	.51	11.307	0.005	3	.49	10.847	0.007	2	.51	10.404	0.005	3
2452792	.50	11.611	0.015	2	.47	11.737	0.014	3	.48	11.365	0.003	3	.48	10.918	0.002	3	.48	10.450	0.001	3
2452793	.50	11.604	0.019	2	.53	11.768	0.018	3	.55	11.403	0.002	3	.53	10.949	0.009	3	.55	10.491	0.002	3

Table B.35. continued.

<i>JD</i>	<i>JD+</i>	<i>U</i>	σ_U	<i>N_U</i>	<i>JD+</i>	<i>B</i>	σ_B	<i>N_B</i>	<i>JD+</i>	<i>V</i>	σ_V	<i>N_V</i>	<i>JD+</i>	<i>R_C</i>	σ_{R_C}	<i>N_{R_C}</i>	<i>JD+</i>	<i>I_C</i>	σ_{I_C}	<i>N_{I_C}</i>
2452794	.48	11.662	0.002	2	.50	11.807	0.003	3	.51	11.437	0.002	3	.50	10.976	0.007	3	.51	10.507	0.008	3
2452795	.47	11.649	0.011	2	.51	11.792	0.010	3	.51	11.426	0.007	4	.49	10.978	0.005	3	.52	10.499	0.008	4
2452796	...	...	...	...	.50	11.754	...	1	.61	11.382	0.012	2	.52	10.945	...	1	.52	10.479	...	1
2452798	.45	11.538	0.006	2	.49	11.671	0.004	3	.50	11.312	0.003	4	.49	10.873	0.004	3	.50	10.413	0.003	4
2452799	.52	11.482	0.012	4	.52	11.626	0.015	4	.53	11.277	0.005	3	.53	10.842	0.004	3	.53	10.383	0.001	3
2452800	.48	11.405	...	1	.48	11.560	0.007	3	.49	11.207	0.006	4	.48	10.788	0.004	3	.50	10.336	0.004	4
2452801	.55	11.348	0.005	2	.54	11.480	0.005	4	.54	11.134	0.004	4	.54	10.709	0.003	3	.54	10.266	0.003	3
2452802	.52	11.221	0.032	2	.50	11.387	0.004	4	.54	11.053	0.004	5	.50	10.640	0.012	4	.51	10.204	0.005	4
2452803	.53	11.179	0.002	3	.51	11.314	0.002	4	.52	10.976	0.002	4	.52	10.564	0.005	4	.52	10.148	0.002	4
2452804	.53	11.113	0.001	2	.50	11.265	0.006	3	.62	10.921	0.009	4	.52	10.526	0.005	4	.52	10.100	0.004	4
2452805	.59	11.084	...	1	.53	11.228	0.002	4	.54	10.890	0.003	4	.53	10.486	0.001	4	.54	10.065	0.004	4
2452806	.58	11.064	...	1	.57	11.212	0.002	2	.60	10.880	0.001	3	.58	10.472	0.005	2	.58	10.049	0.003	2
2452807	.53	11.045	0.001	2	.51	11.204	0.006	4	.54	10.858	0.001	5	.51	10.466	0.007	4	.51	10.041	0.004	4
2452808	.44	11.031	0.003	2	.47	11.194	0.013	3	.47	10.853	0.006	3	.47	10.455	0.003	3	.47	10.013	0.005	3
2452809	.51	11.071	...	1	.54	11.202	0.009	2	.54	10.853	0.008	2	.54	10.440	0.013	2	.54	10.002	0.009	2
2452810	...	...	...	...	.54	11.213	...	1	.68	10.841	0.008	2	.56	10.461	...	1	.54	10.019	...	1
2452811	.51	11.040	...	1	.47	11.210	0.000	2	.47	10.847	0.003	2	.43	10.460	...	1	.43	10.024	...	1
2452812	.47	10.990	...	1	.50	11.192	0.010	2	.57	10.856	0.004	3	.51	10.449	0.000	2	.50	10.009	0.007	2
2452813	.44	10.951	...	1	.41	11.184	0.013	2	.41	10.833	0.015	2	.41	10.446	0.003	2	.41	10.004	0.006	2
2452814	...	...	...	...	.47	11.217	...	1	.47	10.852	...	1	.47	10.460	...	1	.47	10.006	...	1
2452815	.52	11.014	...	1	.50	11.174	...	1	.50	10.835	...	1	.50	10.428	...	1	.50	10.009	...	1
2452817	.48	10.999	...	1	.48	11.174	...	1	.48	10.850	...	1	.48	10.413	...	1	.48	10.001	...	1
2452818	.46	10.987	...	1	.46	11.191	...	1	.43	10.855	0.005	2	.46	10.461	...	1	.46	10.002	...	1
2452820	.45	11.020	...	1	.45	11.165	...	1	.45	10.836	...	1	.45	10.429	...	1	.45	10.003	...	1
2452821	.52	11.008	0.013	2	.52	11.182	0.009	2	.53	10.840	0.011	2	.55	10.427	...	1	.55	10.004	...	1
2452823	.51	10.965	...	1	.51	11.151	...	1	.51	10.820	...	1	.51	10.419	...	1	.51	9.985	...	1
2452824	...	...	...	...	.40	11.196	...	1	.40	10.839	...	1	.40	10.445	...	1	.40	10.025	...	1
2452825	.51	10.972	0.001	2	.51	11.173	0.024	2	.51	10.837	0.027	2	.51	10.431	0.003	2	.51	9.995	0.008	2
2452826	.57	10.971	...	1	.57	11.200	...	1	.57	10.873	...	1	.57	10.442	...	1	.57	10.009	...	1
2452827	.47	10.969	...	1	.47	11.180	...	1	.47	10.853	...	1	...	...	...	...	.47	9.984	...	1
2452832	.47	10.995	...	1	.50	11.186	...	1	.47	10.860	...	1	.49	10.450	...	1	.50	10.036	...	1
2452834	.45	10.978	...	1	.45	11.168	...	1	.46	10.838	...	1	.45	10.426	...	1	.45	10.010	...	1
2452836	.55	10.959	...	1	.53	11.155	...	1	.54	10.823	...	1	.54	10.410	...	1	.54	10.000	...	1
2452837	.47	10.948	0.011	2	.48	11.144	0.007	2	.48	10.836	0.009	2	.47	10.413	0.012	2	.49	9.991	0.002	3
2452838	...	...	...	...	.39	11.160	...	1	.39	10.828	...	1	.39	10.423	...	1	.38	10.008	...	1
2452841	...	...	...	...	...	...	...	...	.48	10.837	...	1	...	...	...	...	.48	9.988	...	1
2452853	.53	10.941	...	1	.53	11.144	...	1	.53	10.818	...	1	.53	10.398	...	1	.53	9.993	...	1
2452856	.51	10.916	...	1	.51	11.119	...	1	.51	10.817	...	1	.51	10.401	...	1	.51	9.967	...	1
2452863	.49	10.914	...	1	.49	11.151	...	1	.49	10.812	...	1	.49	10.425	...	1	.49	10.012	...	1
2452869	.45	10.965	...	1	.45	11.148	...	1	.45	10.847	...	1	.45	10.426	...	1	.45	9.994	...	1
2452872	...	...	...	...	...	...	...	...	.47	10.843	...	1	...	...	...	...	.47	9.994	...	1
2452885	...	...	...	...	...	...	...	...	.61	10.842	...	1	...	...	...	...	.61	9.986	...	1
2452887	...	...	...	...	...	...	...	...	.62	10.840	...	1	...	...	...	...	.62	9.984	...	1
2452888	.56	10.923	...	1	.56	11.144	...	1	.59	10.824	0.006	2	.56	10.391	...	1	.59	9.991	0.016	2
2452889	...	...	...	...	...	...	...	...	.63	10.834	...	1	...	...	...	...	.63	9.982	...	1
2452929	.42	10.940	...	1	.42	11.130	...	1	.42	10.810	...	1	.42	10.418	...	1	.42	9.959	...	1
2452985	.29	10.919	...	1	.29	11.089	...	1	.29	10.779	...	1	.29	10.406	...	1	.29	9.951	...	1
2453008	.37	10.941	...	1	.37	11.107	...	1	.37	10.814	...	1	.37	10.407	...	1	.37	9.993	...	1
2453035	.29	10.982	...	1	.29	11.130	...	1	.29	10.827	...	1	.29	10.422	...	1	.29	9.997	...	1
2453057	.26	10.914	...	1	.26	11.123	...	1	.26	10.800	...	1	.26	10.397	...	1	.26	9.974	...	1
2453124	.53	10.983	...	1	.53	11.126	...	1	.53	10.778	...	1	.53	10.386	...	1	.53	9.971	...	1
2453150	.42	10.964	...	1	.42	11.146	...	1	.42	10.815	...	1	.42	10.400	...	1	.42	9.958	...	1
2453159	.45	10.896	...	1	.45	11.122	...	1	.45	10.780	...	1	.45	10.374	...	1	.45	9.933	...	1
2453170	.47	10.924	...	1	.47	11.122	...	1	.47	10.809	...	1	.47	10.362	...	1	.47	9.923	...	1
2453202	.49	10.887	...	1	.49	11.127	...	1	.49	10.790	...	1	.49	10.377	...	1	.49	9.915	...	1

Table B.35. continued.

<i>JD</i>	<i>JD+</i>	<i>U</i>	σ_U	<i>N_U</i>	<i>JD+</i>	<i>B</i>	σ_B	<i>N_B</i>	<i>JD+</i>	<i>V</i>	σ_V	<i>N_V</i>	<i>JD+</i>	<i>R_C</i>	σ_{R_C}	<i>N_{R_C}</i>	<i>JD+</i>	<i>I_C</i>	σ_{I_C}	<i>N_{I_C}</i>
2453226	.46	10.919	...	1	.46	11.144	...	1	.46	10.787	...	1	.46	10.367	...	1	.46	9.926	...	1
2453249	.58	10.894	...	1	.58	11.132	...	1	.58	10.766	...	1	.58	10.356	...	1	.58	9.933	...	1
2453291	.49	10.877	...	1	.49	11.084	...	1	.49	10.779	...	1	.49	10.367	...	1	.49	9.945	...	1
2453545	.45	10.938	...	1	.45	11.128	...	1	.44	10.769	...	1	.46	10.367	...	1	.46	9.978	...	1
2453580	.58	10.948	...	1	.57	11.120	...	1	.57	10.756	...	1	.57	10.362	...	1	.58	9.971	...	1
2453602	.45	10.945	...	1	.44	11.122	...	1	.44	10.764	...	1	.45	10.370	...	1	.45	9.983	...	1
2453613	.54	10.948	...	1	.54	11.127	...	1	.54	10.765	...	1	.55	10.376	...	1	.55	9.983	...	1
2453648	.40	10.952	...	1	.41	11.131	...	1	.41	10.775	...	1	.41	10.375	...	1	.41	9.986	...	1
2453663	.37	10.946	...	1	.37	11.132	...	1	.37	10.776	...	1	.37	10.384	...	1	.37	9.989	...	1
2453745	.22	10.929	...	1	.22	11.127	...	1	.22	10.764	...	1	.23	10.369	...	1	.23	9.973	...	1
2453760	.28	11.021	...	1	.28	11.133	...	1	.27	10.769	...	1	.29	10.371	...	1	.29	9.968	...	1
2453863	.52	10.951	...	1	.51	11.127	...	1	.51	10.766	...	1	.50	10.372	...	1	.50	9.977	...	1
2453868	...	...	...	...	...	...	...	...	.53	10.715	...	1	.53	10.362	...	1	.53	9.975	...	1
2453899	.47	10.939	...	1	.46	11.137	...	1	.46	10.782	...	1	.47	10.368	...	1	.47	9.979	...	1
2453940	.41	10.943	...	1	.40	11.135	...	1	.40	10.779	...	1	.42	10.372	...	1	.42	9.974	...	1
2453983	.45	10.966	...	1	.45	11.131	...	1	.44	10.758	...	1	.44	10.382	...	1	.44	9.982	...	1
2454024	.43	10.968	...	1	.43	11.125	...	1	.42	10.759	...	1	.44	10.381	...	1	.44	9.985	...	1
2454128	.39	10.963	...	1	.39	11.126	...	1	.38	10.763	...	1	.40	10.377	...	1	.40	9.982	...	1
2454249	.48	10.947	...	1	.47	11.150	...	1	.47	10.793	...	1	.48	10.380	...	1	.48	9.982	...	1
2454290	.51	10.954	...	1	.51	11.147	...	1	.50	10.793	...	1	.50	10.379	...	1	.50	9.980	...	1
2454321	.40	10.938	...	1	.40	11.160	...	1	.40	10.787	...	1	.41	10.380	...	1	.41	9.984	...	1
2454382	.44	10.963	...	1	.43	11.133	...	1	.43	10.775	...	1	.43	10.384	...	1	.44	9.999	...	1
2454407	.31	10.940	...	1	.30	11.128	...	1	.30	10.769	...	1	.30	10.378	...	1	.30	9.982	...	1
2454530	...	...	...	...	.23	11.132	...	1	.23	10.775	...	1	.24	10.372	...	1	.24	9.987	...	1
2454536	...	...	...	...	.27	11.129	...	1	.27	10.762	...	1	.27	10.373	...	1	.27	9.979	...	1
2454571	.58	10.963	...	1	.58	11.137	...	1	.58	10.780	...	1	.59	10.379	...	1	.59	9.991	...	1
2454606	.45	10.956	...	1	.44	11.129	...	1	.44	10.767	...	1	.44	10.370	...	1	.44	9.982	...	1
2454621	...	...	...	...	.38	11.134	...	1	.38	10.766	...	1	.38	10.374	...	1	.37	9.990	...	1
2454648	.43	10.952	...	1	.43	11.136	...	1	.42	10.773	...	1	.42	10.382	...	1	.43	9.994	...	1
2454662	.42	10.950	...	1	.41	11.136	...	1	.41	10.776	...	1	.42	10.386	...	1	.42	9.994	...	1
2454677	.41	10.955	...	1	.41	11.129	...	1	.40	10.769	...	1	.41	10.377	...	1	.41	9.990	...	1
2454700	...	...	...	...	.40	11.146	...	1	.39	10.787	...	1	.40	10.392	...	1	.40	10.005	...	1
2454720	.49	10.964	...	1	.48	11.143	...	1	.48	10.779	...	1	.49	10.379	...	1	.49	10.001	...	1
2454734	.58	10.945	...	1	.57	11.127	...	1	.57	10.772	...	1	.57	10.370	...	1	.58	9.981	...	1
2454735	.29	10.964	...	1	.29	11.156	...	1	.28	10.783	...	1	.28	10.391	...	1	.29	10.002	...	1
2454742	.28	10.966	...	1	.27	11.156	...	1	.27	10.788	...	1	.28	10.395	...	1	.28	10.001	...	1
2454750	.25	10.969	...	1	.24	11.144	...	1	.24	10.783	...	1	.26	10.392	...	1	.26	10.006	...	1
2454751	...	...	...	...	.50	11.142	...	1	.50	10.803	...	1	.50	10.401	...	1	...	...	...	...
2454753	...	...	...	...	.29	11.137	...	1	.29	10.802	...	1	.30	10.401	...	1	...	...	...	...
2454757	.25	10.957	...	1	.24	11.149	...	1	.24	10.781	...	1	.25	10.391	...	1	.25	10.003	...	1
2454758	...	...	...	...	.65	11.125	...	1	.65	10.788	...	1	.65	10.379	...	1	.65	9.984	...	1
2454759	...	...	...	...	.55	11.102	...	1	.54	10.749	...	1	.55	10.374	...	1	.55	9.971	...	1
2454761	.31	10.949	...	1	.32	11.142	...	1	.32	10.775	...	1	.32	10.387	...	1	.32	9.995	...	1
2454762	.20	10.957	...	1	.22	11.142	0.006	2	.23	10.776	0.001	2	.23	10.386	0.002	2	.20	9.999	...	1
2454763	.20	10.960	...	1	.20	11.141	...	1	.21	10.782	...	1	.21	10.388	...	1	.21	10.002	...	1
2454764	.20	10.957	...	1	.20	11.136	...	1	.20	10.766	...	1	.20	10.378	...	1	.20	9.989	...	1
2454766	...	...	...	...	.38	11.134	...	1	.38	10.763	...	1	.38	10.371	...	1	.38	9.990	...	1
2454770	...	...	...	...	...	...	...	...	.59	10.792	...	1	.59	10.388	...	1	.59	10.002	...	1
2454771	.37	10.965	...	1	.37	11.138	...	1	.37	10.781	...	1	.38	10.390	...	1	.38	10.001	...	1
2454773	...	...	...	...	.45	11.149	...	1	.45	10.813	...	1	.45	10.399	...	1	...	...	...	...
2454774	...	...	...	...	.25	11.159	...	1	.28	10.787	...	1	.29	10.389	...	1	.29	10.002	...	1
2454774	.58	11.018	...	1	.58	11.159	...	1	.58	10.787	...	1	.58	10.389	...	1	.58	10.002	...	1
2454775	...	...	...	...	.31	11.200	...	1	.30	10.789	...	1	.29	10.405	...	1	.30	10.015	...	1
2454780	.21	10.963	...	1	.21	11.154	0.006	2	.21	10.795	0.013	2	.22	10.406	0.001	2	.23	10.012	...	1
2454781	...	...	...	...	.21	11.142	0.003	2	.22	10.792	0.016	2	.26	10.407	...	1	...	...	...	...

Table B.35. continued.

<i>JD</i>	<i>JD+</i>	<i>U</i>	σ_U	<i>N_U</i>	<i>JD+</i>	<i>B</i>	σ_B	<i>N_B</i>	<i>JD+</i>	<i>V</i>	σ_V	<i>N_V</i>	<i>JD+</i>	<i>R_C</i>	σ_{R_C}	<i>N_{R_C}</i>	<i>JD+</i>	<i>I_C</i>	σ_{I_C}	<i>N_{I_C}</i>
2454782	...	...	...	...	.22	11.147	...	1	.20	10.779	...	1	...	...	...	...	...	...	...	...
2454782	...	...	...	...	.50	11.145	...	1	.50	10.803	...	1	.50	10.394	...	1	...	...	...	...
2454784	.28	10.971	...	1	.27	11.152	...	1	.27	10.790	...	1	.27	10.393	...	1	.27	9.998	...	1
2454786	...	...	...	...	.25	11.142	...	1	.26	10.802	...	1	.26	10.396	...	1	...	...	...	...
2454789	.18	10.949	...	1	.19	11.141	...	1	.19	10.783	...	1	.19	10.391	...	1	.19	9.996	...	1
2454790	...	...	...	...	.60	11.135	0.002	2	.60	10.784	0.004	2	.60	10.385	0.005	2	.60	9.977	0.009	2
2454791	...	...	...	...	.38	11.148	...	1	.38	10.784	...	1	.38	10.387	...	1	.38	10.000	...	1
2454791	...	...	...	...	.76	11.148	0.005	2	.76	10.787	0.001	2	.76	10.388	0.002	2	.76	9.987	0.009	2
2454792	...	...	...	...	.45	11.137	...	1	.45	10.771	...	1	.45	10.385	...	1	.45	9.995	...	1
2454792	...	...	...	...	.71	11.167	...	1	.71	10.791	...	1	.71	10.396	...	1	.71	9.978	...	1
2454793	.31	10.953	...	1	.30	11.139	...	1	.30	10.781	...	1	.30	10.387	...	1	.30	9.999	...	1
2454795	...	...	...	...	.25	11.149	...	1	.26	10.819	...	1	.25	10.413	...	1	...	...	...	...
2454796	...	...	...	...	.17	11.142	...	1	.18	10.778	...	1	.18	10.384	...	1	.18	9.982	...	1
2454798	...	...	...	...	.18	11.141	0.001	2	.18	10.782	0.002	2	.18	10.391	0.001	2	.18	9.992	0.001	2
2454799	.17	10.963	...	1	.17	11.157	0.001	2	.17	10.789	0.004	2	.17	10.400	0.001	2	.17	10.005	0.000	2
2454800	...	...	...	...	.34	11.162	...	1	.34	10.789	...	1	.34	10.392	...	1	.34	9.996	...	1
2454800	...	...	...	...	.62	11.164	...	1	.62	10.793	...	1	...	...	...	...	...	...	...	...
2454801	.35	10.957	0.015	2	.34	11.162	0.004	2	.34	10.790	0.002	2	.34	10.402	0.001	2	.35	10.009	0.001	2
2454801	...	...	...	...	.58	11.152	0.001	2	.58	10.792	0.004	2	.58	10.398	0.002	2	.58	9.994	0.002	2
2454802	.36	10.952	...	1	.36	11.146	...	1	.37	10.788	...	1	.36	10.393	...	1	.37	9.998	...	1
2454803	.18	10.961	...	1	.18	11.155	...	1	.18	10.794	...	1	.18	10.402	...	1	.18	10.008	...	1
2454804	.18	10.965	0.009	2	.17	11.155	0.005	3	.17	10.788	0.003	3	.18	10.399	0.003	3	.18	10.001	0.003	3
2454804	...	...	...	...	.66	11.158	0.003	3	.66	10.792	0.008	3	.72	10.410	...	1	.72	10.010	0.004	2
2454806	...	...	...	...	.68	11.165	0.002	2	.68	10.797	0.001	2	.68	10.410	...	1	.68	10.007	0.001	2
2454807	.18	10.969	...	1	.18	11.164	0.004	2	.18	10.799	0.002	2	.18	10.408	0.002	2	.18	10.013	0.003	2
2454807	...	...	...	...	.74	11.170	0.003	2	.74	10.794	0.007	2	.74	10.430	...	1	.74	10.012	0.004	2
2454808	.38	10.987	0.006	2	.38	11.166	0.004	2	.38	10.794	0.014	2	.38	10.405	0.008	2	.38	10.002	0.007	2
2454808	...	...	...	...	.50	11.173	...	1	.50	10.805	...	1	...	...	...	...	...	...	...	...
2454809	...	...	...	...	.17	11.173	...	1	.17	10.809	...	1	.17	10.415	...	1	.17	10.010	...	1
2454809	...	...	...	...	.73	11.172	0.001	2	.73	10.809	0.002	2	.73	10.418	0.002	2	.73	10.020	0.017	2
2454810	.24	10.995	0.008	3	.25	11.171	0.003	5	.24	10.804	0.002	5	.25	10.413	0.002	5	.24	10.015	0.001	6
2454810	...	...	...	...	.63	11.183	0.001	3	.63	10.811	0.004	3	.64	10.428	0.002	2	.64	10.027	0.001	2
2454811	...	...	...	...	.15	11.172	...	1	...	...	...	...	.15	10.417	...	1	.15	10.015	...	1
2454811	.62	10.980	...	1	.67	11.181	0.002	3	.67	10.810	0.001	3	.67	10.413	0.002	3	.67	10.017	0.003	3
2454812	...	...	...	...	.60	11.173	0.005	3	.60	10.807	0.003	3	.66	10.418	0.002	2	.66	10.017	0.001	2
2454813	...	...	...	...	.49	11.193	...	1	.49	10.821	...	1	...	...	...	...	...	...	...	...
2454814	.25	11.017	0.005	2	.25	11.196	0.003	4	.25	10.832	0.004	4	.25	10.436	0.002	4	.26	10.033	0.006	3
2454815	.24	11.015	0.006	2	.29	11.194	0.003	5	.29	10.824	0.003	5	.26	10.429	0.001	4	.26	10.022	0.003	4
2454816	.19	11.006	0.006	2	.24	11.182	0.004	4	.24	10.811	0.005	4	.19	10.426	0.002	2	.19	10.027	0.005	3
2454816	...	...	...	...	.69	11.184	0.004	3	.69	10.822	0.005	3	.72	10.416	0.006	2	.72	10.024	0.002	2
2454817	...	...	...	...	.22	11.205	...	1	.26	10.832	0.001	2	.23	10.431	...	1	.23	10.033	...	1
2454817	...	...	...	...	.60	11.198	...	1	.60	10.821	...	1	...	...	...	...	...	...	...	...
2454818	...	...	...	...	.50	11.183	...	1	.50	10.817	...	1	...	...	...	...	...	...	...	...
2454819	...	...	...	...	.62	11.176	...	1	.61	10.808	...	1	...	...	...	...	...	...	...	...
2454820	...	...	...	...	.23	11.167	...	1	.27	10.805	0.004	2	.25	10.415	...	1	.25	10.034	...	1
2454820	.60	10.991	...	1	.55	11.174	0.003	2	.55	10.803	0.001	2	.61	10.410	...	1	.61	10.018	...	1
2454821	.65	10.989	...	1	.63	11.185	0.001	5	.63	10.813	0.002	5	.68	10.411	0.001	3	.65	10.028	0.003	4
2454822	.18	10.998	...	1	.17	11.181	...	1	.16	10.823	...	1	.17	10.421	...	1	.16	10.023	...	1
2454822	.59	10.998	...	1	.59	11.200	0.008	2	.59	10.815	0.000	2	.60	10.422	...	1	.60	10.031	0.003	2
2454823	...	...	...	...	...	...	...	...	.27	10.821	...	1	...	...	...	...	...	...	...	...
2454823	...	...	...	...	.48	11.193	...	1	.48	10.821	...	1	...	...	...	...	...	...	...	...
2454824	.20	11.019	0.007	2	.26	11.195	0.002	4	.26	10.826	0.003	5	.26	10.435	0.001	4	.26	10.037	0.003	4
2454824	...	...	...	...	.61	11.199	...	1	.61	10.826	...	1	...	...	...	...	...	...	...	...
2454825	...	...	...	...	.17	11.208	...	1	.21	10.847	0.004	2	.17	10.456	...	1	.17	10.045	...	1
2454825	...	...	...	...	.64	11.187	...	1	.63	10.818	...	1	...	...	...	...	.65	10.045	...	1

Table B.35. continued.

<i>JD</i>	<i>JD+</i>	<i>U</i>	σ_U	<i>N_U</i>	<i>JD+</i>	<i>B</i>	σ_B	<i>N_B</i>	<i>JD+</i>	<i>V</i>	σ_V	<i>N_V</i>	<i>JD+</i>	<i>R_C</i>	σ_{R_C}	<i>N_{R_C}</i>	<i>JD+</i>	<i>I_C</i>	σ_{I_C}	<i>N_{I_C}</i>
2454826	...	...	...	...	...	...	...	...	.25	10.871	...	1	...	...	...	...	...	...	...	...
2454826	...	...	...	...	.51	11.224	...	1	.51	10.843	...	1	...	...	...	...	...	...	...	...
2454827	...	...	...	...	.32	11.230	0.002	2	.32	10.867	0.005	2	.32	10.462	0.000	2	.32	10.055	0.000	2
2454827	...	...	...	...	.49	11.224	...	1	.49	10.854	...	1	...	...	...	...	...	...	...	...
2454828	.46	11.145	...	1	.37	11.241	0.006	4	.37	10.861	0.007	4	.37	10.474	0.003	4	.37	10.071	0.003	4
2454828	...	...	...	...	.62	11.254	0.001	3	.61	10.868	0.003	4	.68	10.476	0.006	2	.68	10.079	0.004	2
2454829	.21	11.144	...	1	.22	11.277	0.016	3	.23	10.899	0.004	3	.23	10.504	0.004	3	.23	10.097	0.004	3
2454829	...	...	...	...	.59	11.297	0.006	3	.59	10.914	0.009	4	.58	10.505	0.006	2	.61	10.097	0.001	3
2454830	.28	11.188	0.011	3	.29	11.348	0.002	5	.29	10.950	0.002	5	.29	10.545	0.001	6	.29	10.133	0.003	6
2454830	...	...	...	...	.57	11.341	0.010	4	.57	10.946	0.007	4	.58	10.541	0.010	2	.59	10.120	0.009	3
2454831	.26	11.240	0.002	3	.23	11.383	0.003	6	.23	10.985	0.002	6	.24	10.578	0.002	6	.24	10.162	0.003	6
2454831	...	...	...	...	.55	11.372	0.022	2	.49	10.983	...	1	...	...	...	...	.61	10.149	...	1
2454832	.22	11.230	0.004	3	.22	11.379	0.006	4	.22	10.977	0.003	4	.22	10.572	0.003	4	.22	10.162	0.002	4
2454832	...	...	...	...	.60	11.381	...	1	.59	10.962	...	1	...	...	...	...	.60	10.157	...	1
2454833	...	...	...	...	.18	11.379	...	1	.18	10.981	...	1	.18	10.578	...	1	.18	10.169	...	1
2454833	...	...	...	...	.60	11.359	...	1	.59	10.958	...	1	...	...	...	...	.60	10.151	...	1
2454834	.31	11.223	...	1	.31	11.368	0.004	4	.32	10.970	0.002	4	.32	10.571	0.001	4	.32	10.165	0.002	4
2454834	...	...	...	...	.54	11.351	0.014	2	.53	10.966	0.011	2	...	...	...	...	.58	10.154	...	1
2454835	.22	11.194	0.002	2	.22	11.355	0.004	4	.24	10.967	0.004	3	.24	10.564	0.003	3	.22	10.158	0.004	4
2454835	...	...	...	...	.62	11.357	...	1	.61	10.991	...	1	...	...	...	...	.62	10.171	...	1
2454836	...	...	...	...	.14	11.371	...	1	.24	11.001	0.011	2	.14	10.593	...	1	.14	10.195	...	1
2454836	...	...	...	...	.58	11.390	...	1	.58	11.006	...	1	...	...	...	...	...	...	...	...
2454837	.35	11.313	...	1	.27	11.418	0.001	3	.28	11.030	0.004	3	.28	10.624	0.003	3	.28	10.212	0.005	3
2454837	...	...	...	...	.56	11.436	0.001	2	.54	11.038	0.003	2	.57	10.636	...	1	.57	10.228	...	1
2454838	.26	11.325	0.015	2	.24	11.466	0.002	4	.24	11.075	0.001	3	.25	10.669	0.001	4	.25	10.261	0.004	4
2454838	...	...	...	...	.55	11.480	0.002	3	.55	11.091	0.003	3	.57	10.681	0.001	2	.57	10.275	0.002	2
2454839	.35	11.392	...	1	.30	11.530	0.004	3	.29	11.144	0.005	4	.30	10.730	0.002	3	.23	10.316	0.003	3
2454839	...	...	...	...	.58	11.545	0.010	3	.58	11.154	0.004	3	.57	10.741	0.001	2	.58	10.330	0.003	3
2454840	.23	11.429	0.001	2	.31	11.596	0.005	6	.31	11.188	0.002	6	.31	10.773	0.003	6	.31	10.348	0.002	5
2454840	...	...	...	...	.56	11.607	0.003	4	.55	11.208	0.002	3	.58	10.790	0.001	2	.58	10.363	0.004	3
2454841	.24	11.457	0.000	2	.27	11.620	0.001	3	.26	11.211	0.001	3	.27	10.794	0.003	3	.27	10.363	0.004	3
2454841	...	...	...	...	.56	11.617	0.004	4	.56	11.215	0.004	4	.59	10.796	0.006	2	.58	10.364	0.006	3
2454842	...	...	...	...	.29	11.632	0.006	2	.27	11.223	0.004	3	.28	10.801	0.003	2	.28	10.361	0.003	2
2454842	...	...	...	...	.58	11.620	0.003	3	.58	11.215	0.004	3	.62	10.793	0.003	2	.62	10.357	0.001	2
2454843	.22	11.452	0.004	4	.21	11.613	0.002	7	.21	11.209	0.004	8	.21	10.795	0.001	6	.21	10.362	0.005	7
2454843	...	...	...	...	.57	11.591	0.004	3	.57	11.191	0.006	3	.57	10.780	0.001	2	.58	10.356	0.007	3
2454844	.23	11.413	0.005	4	.23	11.568	0.003	6	.23	11.174	0.006	6	.23	10.768	0.004	6	.23	10.340	0.002	6
2454844	...	...	...	...	.60	11.562	0.005	3	.60	11.156	0.001	3	.61	10.753	0.003	2	.60	10.338	0.003	3
2454845	.23	11.358	0.004	3	.24	11.518	0.008	6	.23	11.130	0.001	5	.24	10.722	0.003	6	.24	10.307	0.004	6
2454845	...	...	...	...	.58	11.500	...	1	.57	11.109	...	1	...	...	...	...	.58	10.283	...	1
2454846	...	...	...	...	...	...	...	...	.27	11.071	...	1	...	...	...	...	...	...	...	...
2454846	...	...	...	...	.57	11.484	0.003	4	.57	11.099	0.003	4	.61	10.698	0.002	2	.60	10.282	0.003	3
2454847	...	...	...	...	.60	11.434	0.002	3	.60	11.068	0.004	3	.61	10.658	0.002	2	.60	10.254	0.003	3
2454848	...	...	...	...	.38	11.423	...	1	.36	11.028	0.007	2	.38	10.630	...	1	.38	10.240	...	1
2454848	...	...	...	...	.55	11.405	0.001	3	.55	11.034	0.003	3	.57	10.630	0.001	2	.57	10.219	0.004	2
2454849	.26	11.246	...	1	.22	11.382	0.001	2	.23	11.006	0.007	3	.22	10.608	0.008	2	.23	10.182	0.003	2
2454849	...	...	...	...	.59	11.372	0.004	3	.59	11.000	0.006	3	.60	10.593	0.003	2	.59	10.181	0.002	3
2454850	.25	11.176	0.009	2	.24	11.352	0.001	3	.24	10.974	0.002	3	.24	10.575	0.003	3	.24	10.166	0.003	3
2454850	...	...	...	...	.58	11.342	0.004	4	.58	10.967	0.001	4	.61	10.556	0.006	2	.61	10.160	0.003	3
2454851	.26	11.171	0.016	3	.27	11.307	0.001	4	.24	10.934	0.003	4	.24	10.543	0.002	4	.24	10.135	0.002	4
2454851	...	...	...	...	.59	11.306	...	1	.58	10.935	...	1	...	...	...	...	.60	10.128	...	1
2454852	...	...	...	...	.25	11.287	0.009	2	.27	10.910	0.005	2	.27	10.520	0.003	2	.27	10.109	0.002	2
2454852	...	...	...	...	.59	11.279	...	1	.58	10.913	...	1	...	...	...	...	.60	10.107	...	1
2454853	...	...	...	...	.57	11.241	0.001	2	.58	10.881	0.006	2	...	...	...	...	.62	10.075	...	1
2454854	...	...	...	...	.23	11.246	0.006	2	.23	10.869	0.006	2	.24	10.464	0.007	2	.24	10.071	0.013	2

Table B.35. continued.

<i>JD</i>	<i>JD+</i>	<i>U</i>	σ_U	N_U	<i>JD+</i>	<i>B</i>	σ_B	N_B	<i>JD+</i>	<i>V</i>	σ_V	N_V	<i>JD+</i>	<i>R_C</i>	σ_{R_C}	N_{R_C}	<i>JD+</i>	<i>I_C</i>	σ_{I_C}	N_{I_C}
2454854	...	...	...	...	.52	11.235	...	1	.52	10.862	...	1	...	...	...	...	...	...	...	...
2454855	.27	11.066	...	1	.29	11.222	0.005	2	.30	10.863	0.012	2	.30	10.453	0.006	2	.29	10.054	0.002	2
2454855	...	...	...	...	.58	11.230	...	1	.58	10.846	...	1	...	...	...	...	.58	10.056	...	1
2454856	...	...	...	...	...	...	...	...	.32	10.851	...	1	...	...	...	...	...	...	...	...
2454856	...	...	...	...	.59	11.220	...	1	.58	10.852	...	1	...	...	...	...	.60	10.051	...	1
2454857	.27	11.013	...	1	.23	11.204	0.008	3	.23	10.827	0.003	3	.23	10.439	0.004	3	.23	10.036	0.003	3
2454857	...	...	...	...	.56	11.198	0.003	4	.56	10.828	0.001	4	.58	10.443	0.003	2	.59	10.030	0.003	3
2454858	.39	11.013	...	1	.28	11.194	0.003	4	.29	10.822	0.006	4	.25	10.433	0.004	3	.25	10.029	0.003	3
2454858	.68	11.016	...	1	.62	11.190	0.003	3	.62	10.815	0.002	3	.62	10.426	0.002	3	.62	10.027	0.002	3
2454859	...	...	...	...	.59	11.179	...	1	.58	10.815	...	1	...	...	...	...	.60	10.020	...	1
2454860	.25	10.989	...	1	.23	11.181	0.003	3	.22	10.807	0.002	3	.22	10.407	0.006	2	.22	10.018	0.004	3
2454860	...	...	...	...	.57	11.179	0.003	4	.57	10.806	0.003	4	.59	10.416	0.006	2	.59	10.015	0.002	3
2454861	...	...	...	...	.58	11.171	0.005	4	.58	10.800	0.003	4	.58	10.400	0.000	3	.59	10.010	0.002	4
2454862	...	...	...	...	.31	11.175	...	1	.31	10.805	...	1	.31	10.408	...	1	.31	10.021	...	1
2454862	...	...	...	...	.57	11.176	0.005	4	.56	10.810	0.003	4	.58	10.403	0.003	2	.59	10.014	0.005	3
2454863	...	...	...	...	...	...	...	...	.31	10.791	...	1	...	...	...	...	...	...	...	...
2454863	...	...	...	...	.56	11.172	0.005	4	.56	10.809	0.006	4	.58	10.403	0.003	2	.59	10.004	0.001	3
2454864	...	...	...	...	.59	11.177	...	1	.59	10.811	...	1	.59	10.421	...	1	.59	10.013	...	1
2454865	.22	11.005	0.007	3	.20	11.173	0.002	5	.21	10.802	0.002	5	.21	10.408	0.001	5	.21	10.016	0.002	5
2454865	...	...	...	...	.58	11.177	0.003	3	.58	10.808	0.009	3	.59	10.413	0.003	2	.59	10.011	0.004	3
2454866	...	...	...	...	.30	11.180	...	1	.32	10.815	...	1	.31	10.403	...	1	.31	10.016	...	1
2454866	...	...	...	...	.55	11.178	0.010	2	.54	10.815	0.013	2	...	...	...	...	.60	10.029	...	1
2454867	...	...	...	...	.56	11.172	0.004	4	.56	10.805	0.008	4	.59	10.411	0.010	2	.59	10.005	0.001	3
2454868	.23	10.990	...	1	.23	11.172	...	1	.23	10.809	...	1	.23	10.415	...	1	.23	10.017	...	1
2454868	...	...	...	...	.55	11.170	0.006	2	.54	10.809	0.011	2	...	...	...	...	.60	10.011	...	1
2454869	.22	10.984	0.004	2	.25	11.169	0.007	3	.26	10.797	0.003	3	.26	10.402	0.002	3	.26	9.997	0.010	3
2454869	...	...	...	...	.56	11.162	0.006	4	.56	10.795	0.008	4	.58	10.378	0.012	2	.58	9.999	0.010	3
2454870	...	...	...	...	.57	11.160	0.007	3	.57	10.799	0.005	3	.59	10.406	0.006	2	.59	10.002	0.006	2
2454871	...	...	...	...	.33	11.167	...	1	.31	10.826	...	1	.30	10.412	...	1	.29	10.002	...	1
2454872	.23	10.988	...	1	.22	11.165	...	1	.22	10.804	...	1	.22	10.404	...	1	.22	10.009	...	1
2454872	.65	10.977	...	1	.62	11.173	0.003	2	.62	10.807	0.012	2	.65	10.400	...	1	.62	10.007	0.000	2
2454874	...	...	...	...	.58	11.177	...	1	.58	10.822	...	1	...	...	...	...	.59	10.009	...	1
2454875	...	...	...	...	.59	11.200	...	1	.58	10.809	...	1	...	...	...	...	.59	9.999	...	1
2454876	...	...	...	...	.57	11.194	...	1	.60	10.826	...	1	...	...	...	...	.58	10.030	...	1
2454877	...	...	...	...	.59	11.213	...	1	.58	10.824	...	1	...	...	...	...	.59	10.022	...	1
2454878	.22	11.010	...	1	.26	11.195	0.001	2	.24	10.817	0.002	3	.24	10.418	0.002	3	.24	10.022	0.007	3
2454879	...	...	...	...	.59	11.188	0.005	2	.59	10.804	0.004	2	.59	10.383	0.003	2	.59	10.017	0.001	2
2454881	...	...	...	...	.23	11.180	...	1	...	...	...	...	...	...	...	...	.23	10.003	...	1
2454881	...	...	...	...	.60	11.197	...	1	.60	10.811	...	1	.60	10.416	...	1	.60	10.023	...	1
2454882	.22	10.998	...	1	.21	11.183	0.008	2	.21	10.818	0.006	2	.21	10.416	0.007	2	.21	10.030	0.005	2
2454882	...	...	...	...	.59	11.187	...	1	.59	10.811	...	1	.59	10.396	...	1	.59	10.018	...	1
2454883	.23	10.996	...	1	.21	11.177	0.006	2	.22	10.802	0.007	2	.22	10.405	0.001	2	.22	9.996	0.010	2
2454884	.23	10.986	0.002	2	.23	11.175	0.001	2	.24	10.805	0.002	2	.24	10.411	0.003	2	.24	10.014	0.004	2
2454885	...	...	...	...	.03	11.172	...	1	.03	10.806	...	1	.03	10.411	...	1	.03	9.993	...	1
2454886	.22	10.981	...	1	.22	11.151	...	1	.22	10.797	...	1	.22	10.391	...	1	.22	9.998	...	1
2454890	...	...	...	...	.02	11.162	...	1	.03	10.796	...	1	.03	10.396	...	1	.03	9.998	...	1
2454891	.29	10.980	...	1	.15	11.157	0.005	2	.15	10.793	0.003	2	.15	10.396	0.000	2	.15	10.000	0.002	2
2454891	.65	10.975	...	1	.65	11.159	...	1	.65	10.790	...	1	.65	10.402	...	1	.65	10.004	...	1
2454893	...	...	...	...	.01	11.142	...	1	.01	10.791	...	1	.01	10.396	...	1	.01	9.993	...	1
2454894	...	...	...	...	.01	11.172	...	1	.01	10.796	...	1	.01	10.396	...	1	.01	10.013	...	1
2454895	...	...	...	...	.02	11.122	...	1	.02	10.751	...	1	.02	10.356	...	1	.02	9.973	...	1
2454903	.25	10.970	...	1	.24	11.149	...	1	.24	10.777	...	1	.24	10.382	...	1	.24	10.000	...	1
2454909	.27	10.955	...	1	.27	11.145	...	1	.27	10.780	...	1	.27	10.397	...	1	.27	10.000	...	1
2454922	.58	10.958	...	1	.57	11.135	...	1	.57	10.788	...	1	.57	10.392	...	1	.58	9.988	...	1
2454938	.52	10.950	...	1	.51	11.138	...	1	.51	10.772	...	1	.52	10.384	...	1	.52	9.989	...	1

Table B.35. continued.

<i>JD</i>	<i>JD+</i>	<i>U</i>	σ_U	N_U	<i>JD+</i>	<i>B</i>	σ_B	N_B	<i>JD+</i>	<i>V</i>	σ_V	N_V	<i>JD+</i>	<i>R_C</i>	σ_{R_C}	N_{R_C}	<i>JD+</i>	<i>I_C</i>	σ_{I_C}	N_{I_C}
2454950	.58	10.970	...	1	.58	11.136	...	1	.57	10.796	...	1	.58	10.381	...	1	.58	9.994	...	1
2455017	.45	10.934	...	1	.44	11.123	...	1	.43	10.763	...	1	.44	10.361	...	1	.44	9.982	...	1
2455027	.50	10.942	...	1	.50	11.130	...	1	.49	10.770	...	1	.50	10.377	...	1	.50	9.983	...	1
2455040	.37	10.946	...	1	...	...	...	...	.35	10.780	...	1	...	...	...	...	...	...	...	...
2455063	.37	10.957	...	1	.36	11.119	...	1	.36	10.779	...	1	.36	10.364	...	1	.36	9.995	...	1
2455083	.33	10.959	...	1	...	...	...	...	.30	10.768	...	1	.30	10.369	...	1	.31	9.984	...	1
2455099	.41	10.939	...	1	.41	11.122	...	1	.40	10.774	...	1	.41	10.373	...	1	.41	9.985	...	1
2455111	.26	10.951	...	1	.25	11.137	...	1	.25	10.775	...	1	.26	10.383	...	1	.25	10.009	...	1
2455120	.24	10.943	...	1	.23	11.131	...	1	.23	10.773	...	1	.23	10.378	...	1	.24	9.983	...	1
2455138	.24	10.945	...	1	.23	11.124	...	1	.23	10.764	...	1	.22	10.369	...	1	.22	9.978	...	1
2455150	.20	10.951	...	1	.20	11.119	...	1	.19	10.757	...	1	.19	10.361	...	1	.19	9.968	...	1
2455156	.28	10.913	...	1	.28	11.130	...	1	.28	10.767	...	1	.28	10.375	...	1	.28	9.975	...	1
2455162	.39	10.962	...	1	.39	11.131	...	1	.39	10.773	...	1	.38	10.376	...	1	.38	9.983	...	1
2455164	.19	10.946	...	1	.19	11.136	...	1	.18	10.772	...	1	.19	10.376	...	1	.19	9.976	...	1
2455210	.21	10.938	...	1	.21	11.123	...	1	.20	10.761	...	1	.21	10.360	...	1	.21	9.959	...	1
2455233	...	...	...	...	.23	11.122	...	1	.23	10.763	...	1	.23	10.355	...	1	.23	9.958	...	1
2455253	.27	10.937	...	1	.26	11.115	...	1	.25	10.751	...	1	.25	10.340	...	1	.25	9.940	...	1
2455264	...	...	...	...	.24	11.121	...	1	.25	10.759	...	1	.25	10.360	...	1	.25	9.949	...	1
2455267	...	...	...	...	.25	11.112	...	1	.25	10.759	...	1	.25	10.356	...	1	.25	9.954	...	1
2455270	...	...	...	...	.65	11.120	...	1	.65	10.756	...	1	.65	10.355	...	1	.65	9.951	...	1
2455271	...	...	...	...	.27	11.120	...	1	.27	10.755	...	1	.27	10.348	...	1	.27	9.955	...	1
2455272	...	...	...	...	.27	11.127	...	1	.27	10.766	...	1	.28	10.360	...	1	.28	9.955	...	1
2455274	.26	10.951	...	1	.25	11.114	...	1	.25	10.763	...	1	.26	10.350	...	1	.25	9.950	...	1
2455294	...	...	...	...	.53	11.124	...	1	.53	10.761	...	1	.53	10.359	...	1	...	...	...	...
2455303	.55	10.938	...	1	.54	11.124	...	1	.54	10.766	...	1	.55	10.359	...	1	.55	9.957	...	1
2455311	.50	10.941	...	1	.50	11.125	...	1	.49	10.761	...	1	.50	10.358	...	1	.50	9.951	...	1

Table B.36. List of spectra obtained during and near the last three eclipses (from $E = 8$ to $E = 10$) and names of the corresponding FITS files.

Date [UT]	HJD-2400000	Phase	Epoch	Observatory	Instrument	Spectral Region	Res.	power	Name of FITS file
1998-07-03 1:05:30	50997.5455	8.12387	8	Rozhen	Ritchey-Chrétien/2.0 Coude	H α		15000	980703.Rozhen.Ha.fits
1998-09-30 20:46:37	51087.3657	8.16769	8	Rozhen	Ritchey-Chrétien/2.0 Coude	H α		15000	980930.Rozhen.Ha.fits
1998-09-30 23:14:09	51087.4682	8.16774	8	Rozhen	Ritchey-Chrétien/2.0 Coude	Na I		15000	980930.Rozhen.NaI.fits
2002-11-19 18:08:37	52598.2560	8.90473	9	Rozhen	Ritchey-Chrétien/2.0 Coude	Na I		15000	021119.Rozhen.NaI.fits
2002-11-19 18:47:34	52598.2830	8.90474	9	Rozhen	Ritchey-Chrétien/2.0 Coude	H α		15000	021119.Rozhen.Ha.fits
2002-11-20 16:03:32	52599.1691	8.90517	9	Rozhen	Ritchey-Chrétien/2.0 Coude	Na I		15000	021120.Rozhen.NaI.fits
2002-11-20 17:11:14	52599.2161	8.90520	9	Rozhen	Ritchey-Chrétien/2.0 Coude	H α		15000	021120.Rozhen.Ha.fits
2003-04-12 2:54:15	52741.6210	8.97466	9	Rozhen	Ritchey-Chrétien/2.0 Coude	Na I		15000	030412.Rozhen.NaI.fits
2003-04-25 1:42:16	52754.5710	8.98098	9	Piwnice	Schmidt-Cassegrain/0.9 CCS	4800-6800 Å		4000	030425.Piwnice.4800_6800.fits
2003-04-26 0:53:20	52755.5370	8.98145	9	Piwnice	Schmidt-Cassegrain/0.9 CCS	4800-6800 Å		4000	030426.Piwnice.4800_6800.fits
2003-04-26 1:57:04	52755.5813	8.98147	9	Asiago	Cassegrain/1.82 AFOSC/echelle	3600-8800 Å		3600	030426.Asiago.3600_8800.fits
2003-04-27 23:19:40	52757.4720	8.98240	9	Piwnice	Schmidt-Cassegrain/0.9 CCS	4800-6800 Å		4000	030427.Piwnice.4800_6800.fits
2003-04-30 2:37:43	52759.6095	8.98344	9	Asiago	Cassegrain/1.82 AFOSC/echelle	3600-8800 Å		3600	030430.Asiago.3600_8800.fits
2003-05-14 21:06:57	52774.3798	8.99064	9	Piwnice	Schmidt-Cassegrain/0.9 CCS	5400-9250 Å		2000	030514.Piwnice.5400_9250.fits
2003-05-16 22:18:17	52776.4294	8.99164	9	Piwnice	Schmidt-Cassegrain/0.9 CCS	5400-9250 Å		2000	030516.Piwnice.5400_9250.fits
2003-05-19 1:28:29	52778.5614	8.99268	9	Asiago	Cassegrain/1.82 Echelle	4600-9200 Å		20000	030519.Asiago.4600_9200.fits
2003-05-22 0:41:38	52781.5289	8.99413	9	Asiago	Cassegrain/1.82 Echelle	4600-9200 Å		20000	030522.Asiago.4600_9200.fits
2003-05-22 22:03:26	52782.4191	8.99457	9	Piwnice	Schmidt-Cassegrain/0.9 CCS	5200-9200 Å		2000	030522.Piwnice.5200_9200.fits
2003-05-28 23:18:36	52788.4713	8.99752	9	Piwnice	Schmidt-Cassegrain/0.9 CCS	5100-8900 Å		2000	030528.Piwnice.5100_8900.fits
2003-06-02 23:07:48	52793.4638	8.99995	9	Piwnice	Schmidt-Cassegrain/0.9 CCS	5100-8900 Å		2000	030602.Piwnice.5100_8900.fits
2003-06-03 0:10:58	52793.5076	8.99997	9	Rozhen	Ritchey-Chrétien/2.0 Coude	H α		15000	030603.Rozhen.Ha.fits
2003-06-03 0:29:25	52793.5204	8.99998	9	Asiago	Cassegrain/1.82 AFOSC/echelle	3600-8800 Å		3600	030603.Asiago.3600_8800.fits
2003-06-03 1:40:59	52793.5701	9.00000	9	Rozhen	Ritchey-Chrétien/2.0 Coude	Na I		15000	030603.Rozhen.NaI.fits
2003-06-03 2:06:55	52793.5881	9.00001	9	Rozhen	Ritchey-Chrétien/2.0 Coude	H β , Fe II		15000	030603.Rozhen.Hb.fits
2003-06-03 22:18:21	52794.4294	9.00042	9	Piwnice	Schmidt-Cassegrain/0.9 CCS	5100-8900 Å		2000	030603.Piwnice.5100_8900.fits
2003-06-06 0:24:01	52796.5167	9.00144	9	Asiago	Cassegrain/1.82 Echelle	4600-9200 Å		20000	030606.Asiago.4600_9200.fits
2003-06-06 22:55:03	52797.4549	9.00190	9	Piwnice	Schmidt-Cassegrain/0.9 CCS	5100-8900 Å		2000	030606.Piwnice.5100_8900.fits
2003-06-06 23:59:17	52797.4995	9.00192	9	Rozhen	Ritchey-Chrétien/2.0 Coude	H α		15000	030606.Rozhen.Ha.fits
2003-06-07 0:32:41	52797.5227	9.00193	9	Rozhen	Ritchey-Chrétien/2.0 Coude	Na I		15000	030607.Rozhen.NaI.fits
2003-06-07 1:15:38	52797.5525	9.00195	9	Rozhen	Ritchey-Chrétien/2.0 Coude	H β , Fe II		15000	030607.Rozhen.Hb.fits
2003-06-07 23:35:41	52798.4831	9.00240	9	Piwnice	Schmidt-Cassegrain/0.9 CCS	5100-8900 Å		2000	030607.Piwnice.5100_8900.fits
2003-06-08 0:10:11	52798.5071	9.00241	9	Rozhen	Ritchey-Chrétien/2.0 Coude	H β , Fe II		15000	030608.Rozhen.Hb.fits
2003-06-09 22:52:27	52800.4531	9.00336	9	Rozhen	Ritchey-Chrétien/2.0 Coude	H β , Fe II		15000	030609.Rozhen.Hb.fits
2003-06-09 23:41:35	52800.4872	9.00338	9	Rozhen	Ritchey-Chrétien/2.0 Coude	Na I		15000	030609.Rozhen.NaI.fits
2003-06-10 0:06:38	52800.5046	9.00339	9	Rozhen	Ritchey-Chrétien/2.0 Coude	H α		15000	030610.Rozhen.Ha.fits
2003-06-10 1:14:20	52800.5516	9.00341	9	Rozhen	Ritchey-Chrétien/2.0 Coude	Na I		15000	030610.Rozhen.NaI.fits
2003-06-10 1:53:09	52800.5786	9.00342	9	Rozhen	Ritchey-Chrétien/2.0 Coude	H β , Fe II		15000	030610.Rozhen.Hb.fits
2003-06-10 23:46:00	52801.4903	9.00387	9	Terskol	Ritchey-Chrétien/2.0 Echelle	4200-6700 Å		13500	030610.Terskol.4200_6700.fits
2003-06-14 23:18:11	52805.4710	9.00581	9	Rozhen	Ritchey-Chrétien/2.0 Coude	H α		30000	030614.Rozhen.Ha.fits
2003-06-15 0:26:51	52805.5186	9.00583	9	Rozhen	Ritchey-Chrétien/2.0 Coude	Na I		30000	030615.Rozhen.NaI.fits
2003-06-15 8:06:43	52805.8380	9.00599	9	DDO	Cassegrain/1.88 Cassegrain	H α		16000	030615.DDO.Ha.fits
2003-06-15 21:30:00	52806.3958	9.00626	9	Terskol	Ritchey-Chrétien/2.0 Echelle	4200-6700 Å		13500	030615.Terskol.4200_6700.fits
2003-06-16 20:39:00	52807.3604	9.00673	9	Terskol	Ritchey-Chrétien/2.0 Echelle	4200-6700 Å		13500	030616.Terskol.4200_6700.fits
2003-06-17 8:09:32	52807.8400	9.00697	9	DDO	Cassegrain/1.88 Cassegrain	H α		16000	030617.DDO.Ha.fits
2003-06-18 7:28:13	52808.8113	9.00744	9	DDO	Cassegrain/1.88 Cassegrain	H α		16000	030618.DDO.Ha.fits
2003-06-18 22:12:19	52809.4252	9.00774	9	Piwnice	Schmidt-Cassegrain/0.9 CCS	5200-8900 Å		2000	030618.Piwnice.5200_8900.fits
2003-06-18 22:53:00	52809.4535	9.00775	9	Terskol	Ritchey-Chrétien/2.0 Echelle	4200-6700 Å		13500	030618.Terskol.4200_6700.fits
2003-06-19 1:14:56	52809.5520	9.00780	9	Asiago	Cassegrain/1.82 Echelle	4600-9200 Å		20000	030619.Asiago.4600_9200.fits
2003-06-19 23:20:00	52810.4722	9.00825	9	Terskol	Ritchey-Chrétien/2.0 Echelle	4200-6700 Å		13500	030619.Terskol.4200_6700.fits
2003-06-20 22:15:00	52811.4271	9.00872	9	Terskol	Ritchey-Chrétien/2.0 Echelle	4200-6700 Å		13500	030620.Terskol.4200_6700.fits
2003-06-22 8:10:49	52812.8408	9.00941	9	DDO	Cassegrain/1.88 Cassegrain	Na I		16000	030622.DDO.NaI.fits
2003-06-23 6:04:32	52813.7531	9.00985	9	DDO	Cassegrain/1.88 Cassegrain	H α		16000	030623.DDO.Ha.fits

Table B.36. continued.

Date [UT]	HJD-2400000	Phase	Epoch	Observatory	Instrument	Spectral Region	Res. power	Name of FITS file
2003-06-23 6:55:27	52813.7885	9.00987	9	DDO	Cassegrain/1.88 Cassegrain	Na I	16000	030623.DDO.NaI.fits
2003-06-24 7:39:04	52814.8188	9.01037	9	DDO	Cassegrain/1.88 Cassegrain	Na I	16000	030624.DDO.NaI.fits
2003-06-25 7:56:06	52815.8306	9.01086	9	DDO	Cassegrain/1.88 Cassegrain	H α	16000	030625.DDO.Ha.fits
2003-06-25 22:35:00	52816.4410	9.01116	9	Terskol	Ritchey-Chrétien/2.0 Echelle	4200-6700 Å	13500	030625.Terskol.4200_6700.fits
2003-06-26 21:52:02	52817.4111	9.01164	9	Piwnice	Schmidt-Cassegrain/0.9 CCS	5150-8900 Å	2000	030626.Piwnice.5150_8900.fits
2003-07-01 7:38:53	52821.8187	9.01379	9	DDO	Cassegrain/1.88 Cassegrain	H α	16000	030701.DDO.Ha.fits
2003-07-02 8:15:36	52822.8442	9.01429	9	DDO	Cassegrain/1.88 Cassegrain	H α	16000	030702.DDO.Ha.fits
2003-07-04 4:37:39	52824.6928	9.01519	9	DDO	Cassegrain/1.88 Cassegrain	H α	16000	030704.DDO.Ha.fits
2003-07-06 8:12:56	52826.8423	9.01624	9	DDO	Cassegrain/1.88 Cassegrain	H α	16000	030706.DDO.Ha.fits
2003-07-08 6:33:45	52828.7734	9.01718	9	DDO	Cassegrain/1.88 Cassegrain	H α	16000	030708.DDO.Ha.fits
2003-07-09 0:20:55	52829.5145	9.01754	9	Rozhen	Ritchey-Chrétien/2.0 Coude	Na I	30000	030709.Rozhen.NaI.fits
2003-07-09 1:18:28	52829.5545	9.01756	9	Rozhen	Ritchey-Chrétien/2.0 Coude	H α	30000	030709.Rozhen.Ha.fits
2003-07-22 22:18:27	52843.4295	9.02433	9	Rozhen	Ritchey-Chrétien/2.0 Coude	H α	15000	030722.Rozhen.Ha.fits
2003-07-28 8:35:39	52848.8581	9.02698	9	DDO	Cassegrain/1.88 Cassegrain	H α	16000	030728.DDO.Ha.fits
2003-07-30 8:36:55	52850.8590	9.02795	9	DDO	Cassegrain/1.88 Cassegrain	H α	16000	030730.DDO.Ha.fits
2003-07-31 7:37:14	52851.8175	9.02842	9	DDO	Cassegrain/1.88 Cassegrain	H α	16000	030731.DDO.Ha.fits
2003-08-11 5:56:22	52862.7475	9.03375	9	SPM	Ritchey-Chrétien/2.12 Echelle	3700-6800 Å	18000	030811.SPM.3700_6800.fits
2003-08-14 21:45:07	52866.4063	9.03554	9	Rozhen	Ritchey-Chrétien/2.0 Coude	H α	15000	030814.Rozhen.Ha.fits
2003-08-14 22:25:52	52866.4346	9.03555	9	Rozhen	Ritchey-Chrétien/2.0 Coude	Na I	15000	030814.Rozhen.NaI.fits
2003-10-12 20:17:00	52925.3451	9.06429	9	Rozhen	Ritchey-Chrétien/2.0 Coude	Na I	15000	031012.Rozhen.NaI.fits
2003-10-12 20:58:00	52925.3736	9.06430	9	Rozhen	Ritchey-Chrétien/2.0 Coude	H α	15000	031012.Rozhen.Ha.fits
2004-03-27 23:27:45	53092.4776	9.14582	9	Piwnice	Schmidt-Cassegrain/0.9 CCS	5500-9500 Å	2000	040327.Piwnice.5500_9500.fits
2004-03-28 2:33:39	53092.6067	9.14588	9	Piwnice	Schmidt-Cassegrain/0.9 CCS	5500-9500 Å	2000	040328.Piwnice.5500_9500.fits
2004-03-29 23:31:12	53094.4800	9.14680	9	Piwnice	Schmidt-Cassegrain/0.9 CCS	5500-9500 Å	2000	040329.Piwnice.5500_9500.fits
2004-10-25 0:28:54	53303.5201	9.24877	9	Asiago	Cassegrain/1.82 Echelle	4600-9200 Å	20000	041025.Asiago.4600_9200.fits
2008-10-14 20:21:05	54754.3480	9.95651	10	Rozhen	Ritchey-Chrétien/2.0 Coude	H α	15000	081014.Rozhen.Ha.fits
2008-10-14 20:52:09	54754.3695	9.95652	10	Rozhen	Ritchey-Chrétien/2.0 Coude	Na I	15000	081014.Rozhen.NaI.fits
2008-12-09 18:37:11	54810.2758	9.98379	10	Piwnice	Schmidt-Cassegrain/0.9 CCS	6500-10500 Å	2000	081209.Piwnice.6500_10500.fits
2008-12-09 19:28:22	54810.3114	9.98381	10	Piwnice	Schmidt-Cassegrain/0.9 CCS	3500-7500 Å	2000	081209.Piwnice.3500_7500.fits
2008-12-09 19:34:00	54810.3153	9.98381	10	Rozhen	Ritchey-Chrétien/2.0 Coude	H α	15000	081209.Rozhen.Ha.fits
2008-12-09 20:23:19	54810.3495	9.98383	10	Rozhen	Ritchey-Chrétien/2.0 Coude	Na I	15000	081209.Rozhen.NaI.fits
2008-12-10 19:11:19	54811.2995	9.98429	10	Rozhen	Ritchey-Chrétien/2.0 Coude	H α	15000	081210.Rozhen.Ha.fits
2008-12-10 19:40:29	54811.3198	9.98430	10	Rozhen	Ritchey-Chrétien/2.0 Coude	Na I	15000	081210.Rozhen.NaI.fits
2008-12-19 20:45:24	54820.3649	9.98871	10	NOT, La Palma	Ritchey-Chrétien/2.56 FIES-Echelle	3680-7280 Å	48000	081219.NOT.3680_7280.fits
2008-12-21 21:33:01	54822.3979	9.98971	10	NOT, La Palma	Ritchey-Chrétien/2.56 FIES-Echelle	3680-7280 Å	48000	081221.NOT.3680_7280.fits
2008-12-28 19:34:40	54829.3157	9.99308	10	NOT, La Palma	Ritchey-Chrétien/2.56 FIES-Echelle	3680-7280 Å	48000	081228.NOT.3680_7280.fits
2009-01-05 19:56:12	54837.3307	9.99699	10	Piwnice	Schmidt-Cassegrain/0.9 CCS	4700-6700 Å	4000	090105.Piwnice.4700_6700.fits
2009-01-06 19:00:18	54838.2919	9.99746	10	Piwnice	Schmidt-Cassegrain/0.9 CCS	4700-6700 Å	4000	090106.Piwnice.4700_6700.fits
2009-01-11 16:23:01	54843.1827	9.99985	10	Rozhen	Ritchey-Chrétien/2.0 Coude	H α	15000	090111.Rozhen.Ha.fits
2009-01-11 17:09:51	54843.2152	9.99986	10	Piwnice	Schmidt-Cassegrain/0.9 CCS	4700-6700 Å	4000	090111.Piwnice.4700_6700.fits
2009-01-11 20:21:41	54843.3484	9.99993	10	Piwnice	Schmidt-Cassegrain/0.9 CCS	4000-8000 Å	2000	090111.Piwnice.4000_8000.fits
2009-01-12 16:47:36	54844.1997	10.00034	10	Rozhen	Ritchey-Chrétien/2.0 Coude	Na I	15000	090112.Rozhen.NaI.fits
2009-01-12 18:04:52	54844.2534	10.00037	10	Rozhen	Ritchey-Chrétien/2.0 Coude	H α	15000	090112.Rozhen.Ha.fits
2009-01-12 18:10:35	54844.2573	10.00037	10	Piwnice	Schmidt-Cassegrain/0.9 CCS	4000-8000 Å	4000	090112.Piwnice.4000_8000.fits
2009-02-11 20:12:01	54874.3417	10.01505	10	NOT, La Palma	Ritchey-Chrétien/2.56 FIES-Echelle	3680-7280 Å	48000	090211.NOT.3680_7280.fits
2009-03-18 2:41:03	54908.6118	10.03176	10	Piwnice	Schmidt-Cassegrain/0.9 CCS	3500-5500 Å	3000	090318.Piwnice.3500_5500.fits
2009-03-18 3:58:29	54908.6656	10.03179	10	Piwnice	Schmidt-Cassegrain/0.9 CCS	5500-7500 Å	4000	090318.Piwnice.5500_7500.fits
2009-03-18 20:54:07	54909.3709	10.03213	10	Piwnice	Schmidt-Cassegrain/0.9 CCS	5500-7500 Å	4000	090318.Piwnice.5500_7500.fits